Practical Electronics

DECEMBER 1964

PRICE 2/6

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2 BLUEPRINTS

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ULTRASONIC REMOTE CONTROL

PRESENTED FREE WITH
DECEMBER 1964
PRACTICAL
electronics

A DECIMAL-STEP PRE-AMPLIFIER

PRICE 5/-

PUBLISHED BY GEO. NEWNES LTD.,
TOWER HOUSE, SOUTHAMPTON STREET,
LONDON, W.C.2.

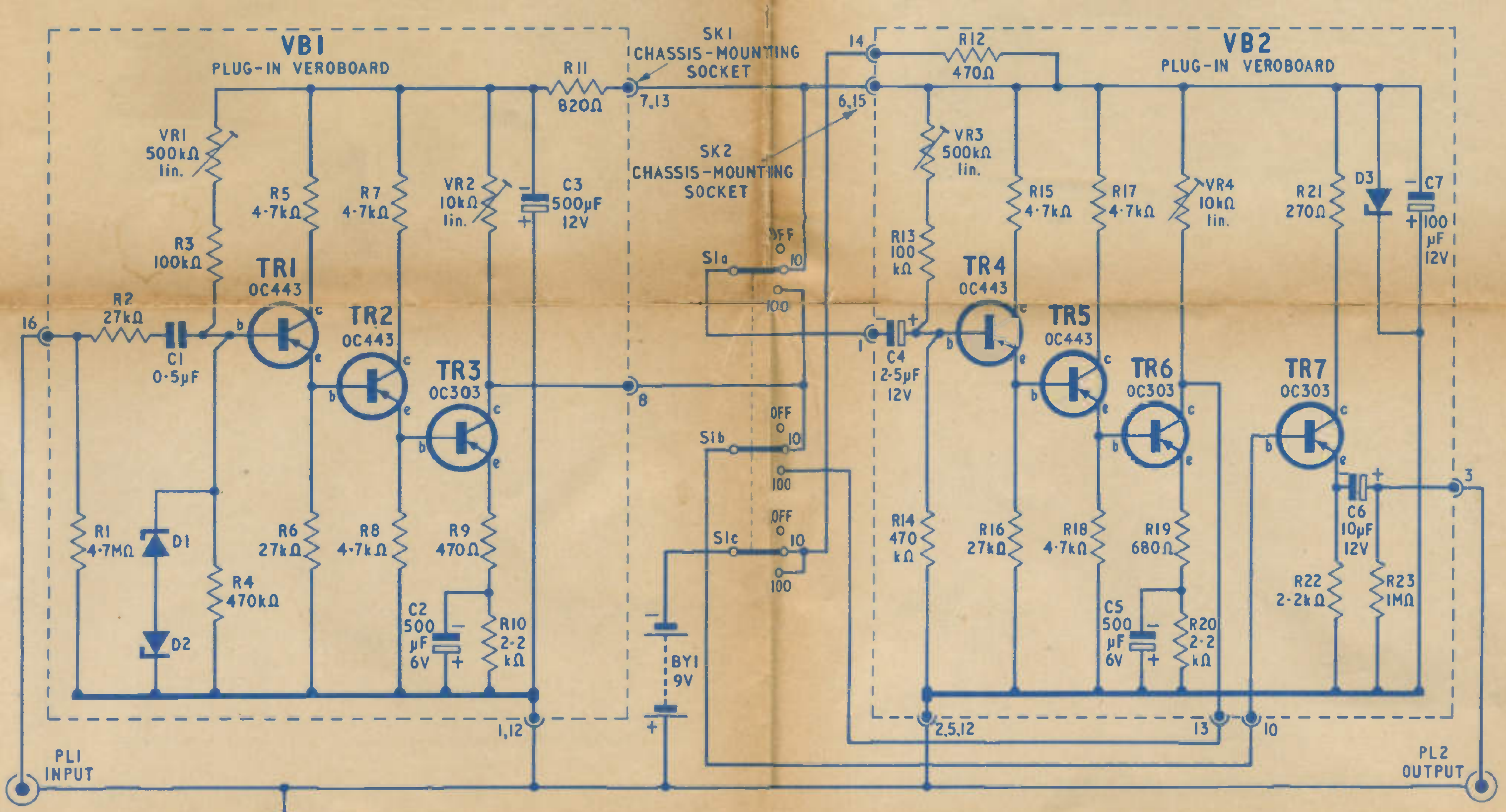

FIG. 1—THE CIRCUIT DIAGRAM

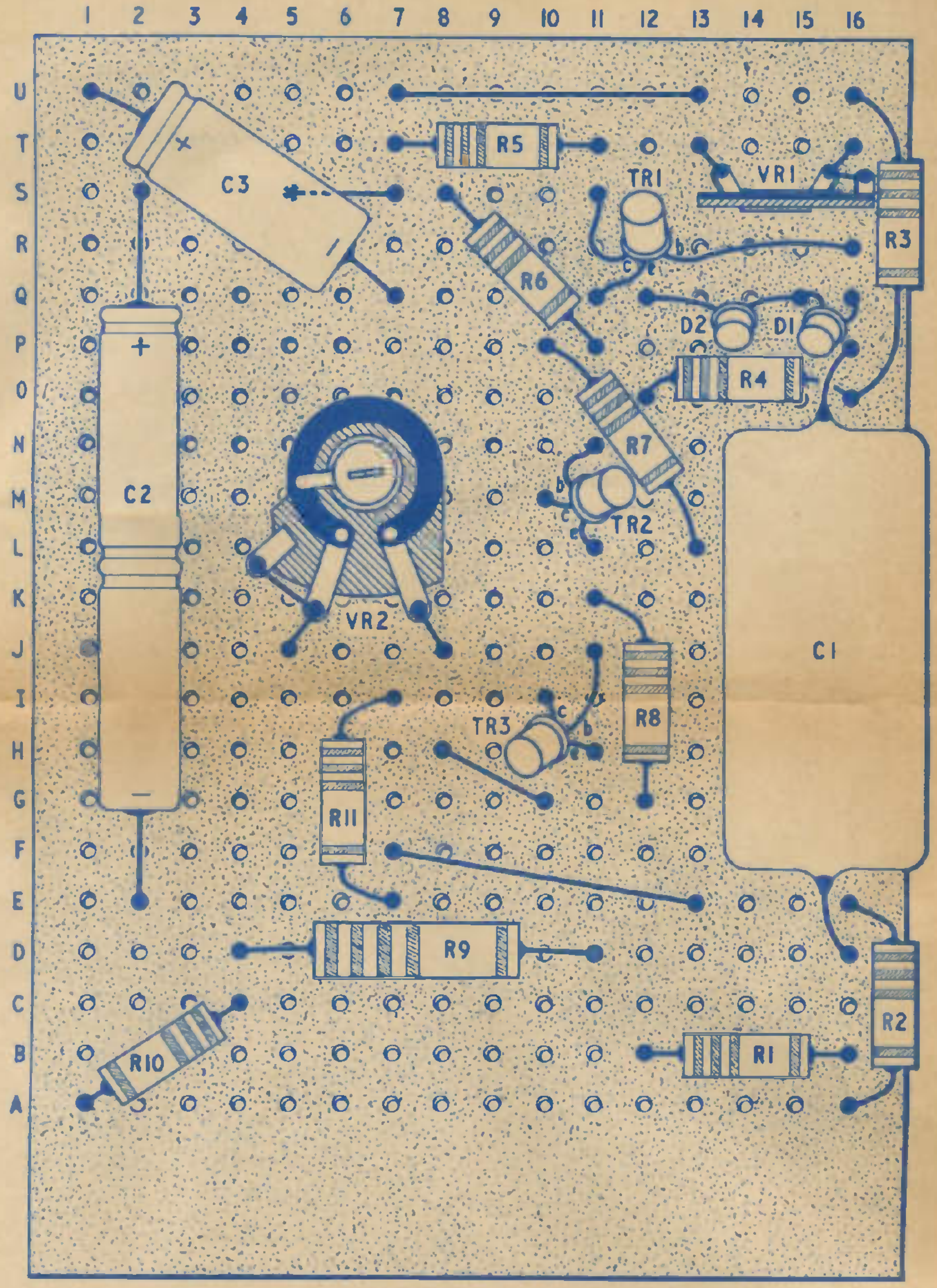

FIG. 2 — COMPONENT LAYOUT OF VB1

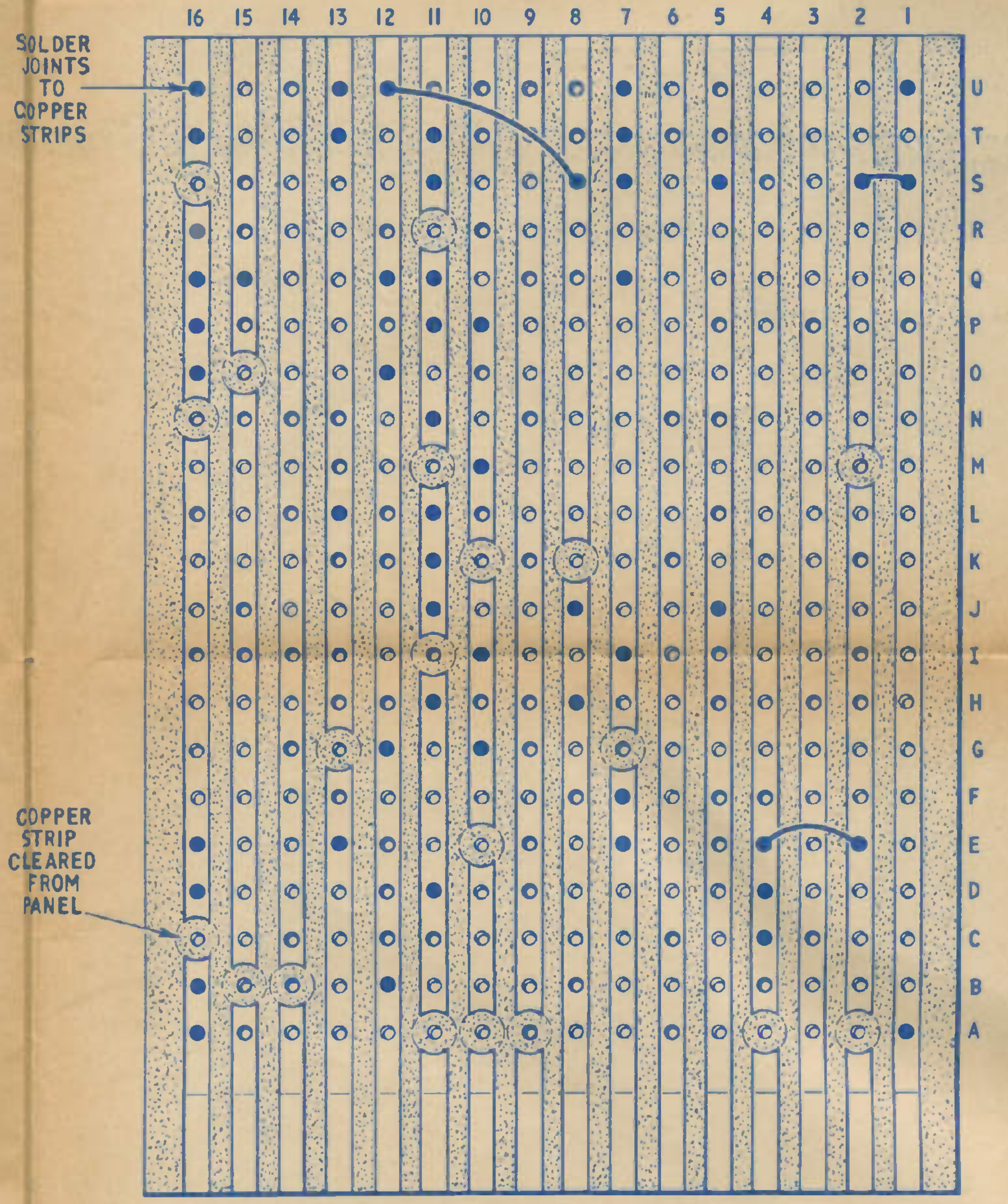

FIG. 3 — COPPER STRIP DETAILS OF VB1

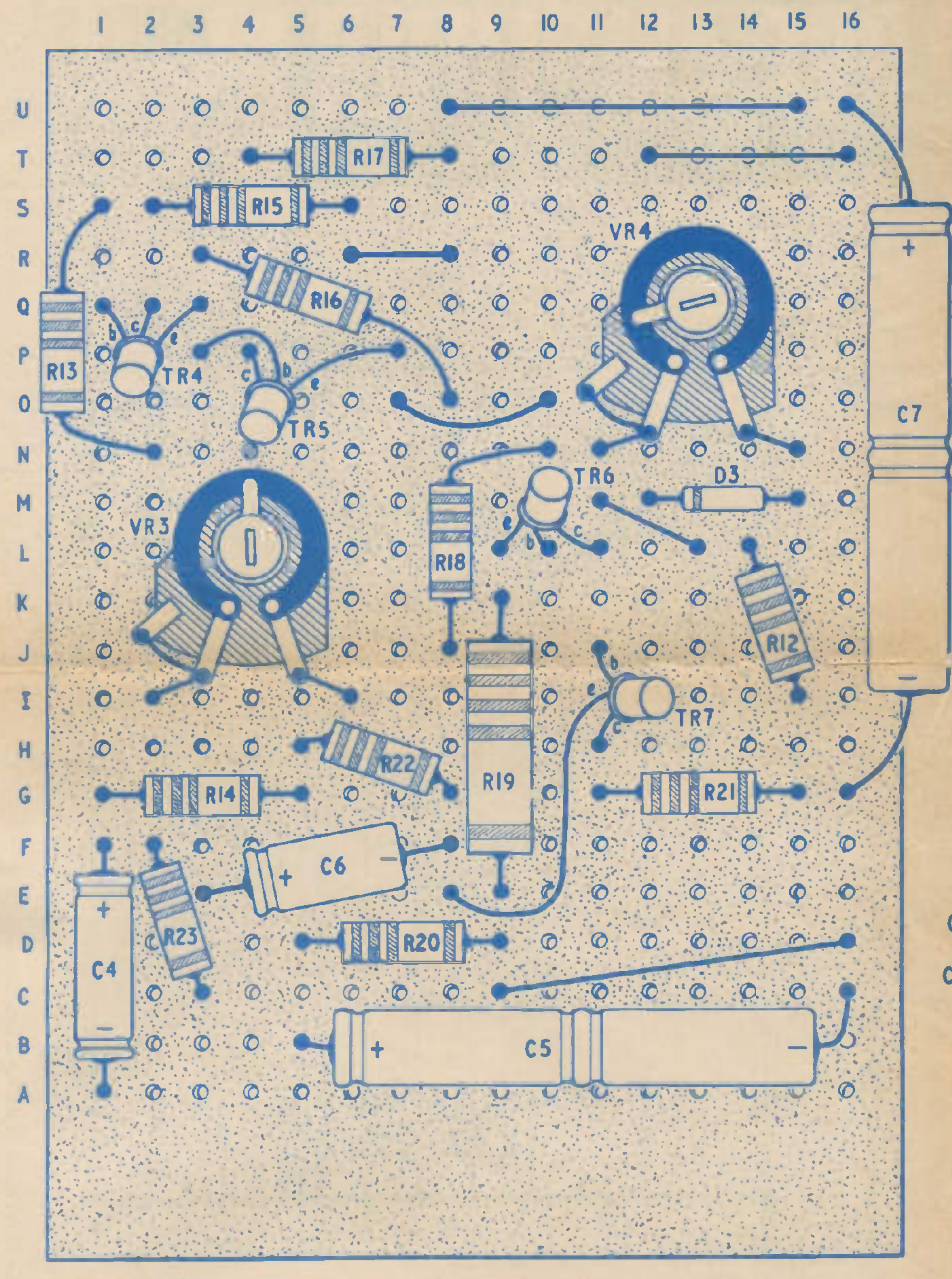

FIG. 4 — COMPONENT LAYOUT OF VB2

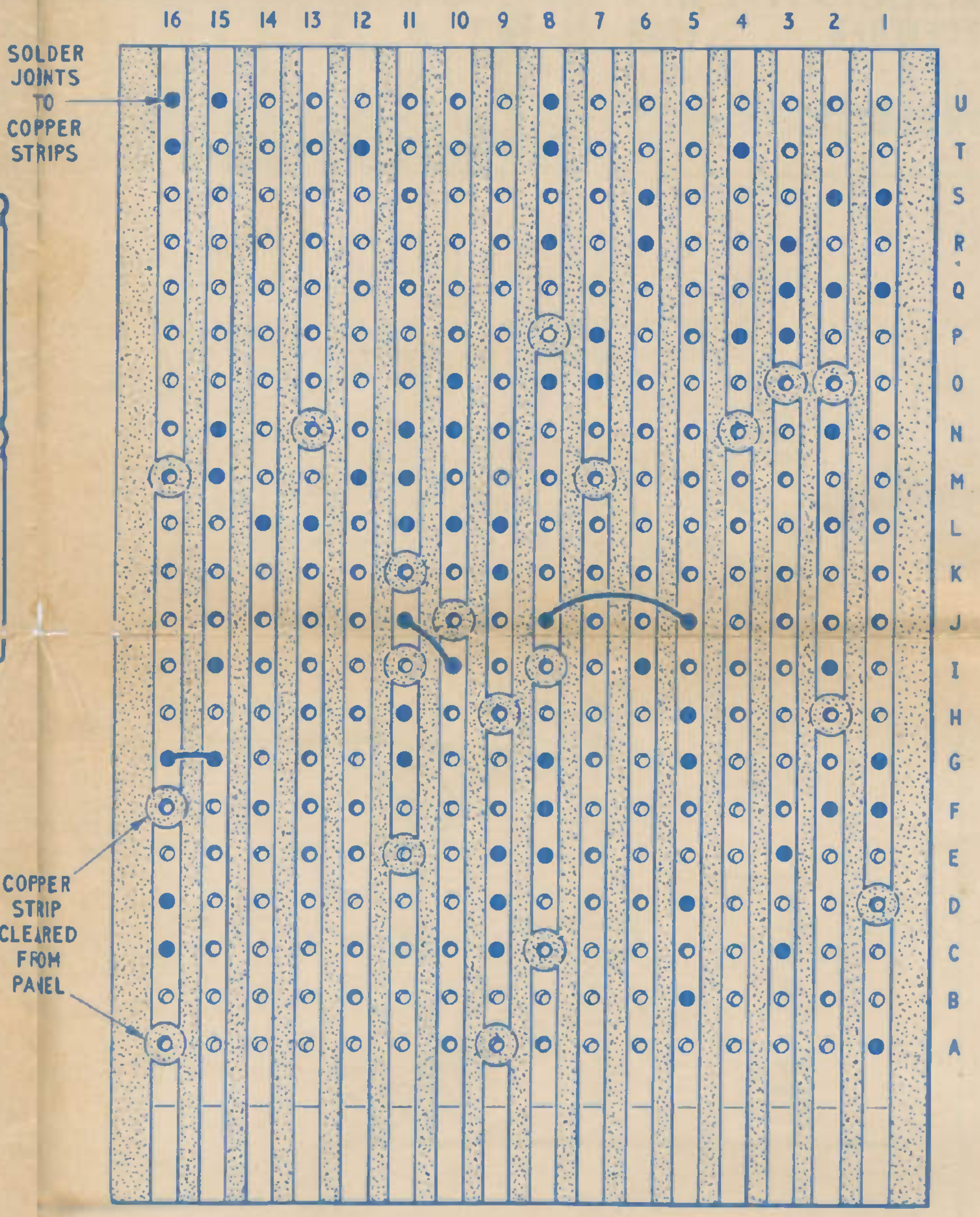

FIG. 5 — COPPER STRIP DETAILS OF VB2

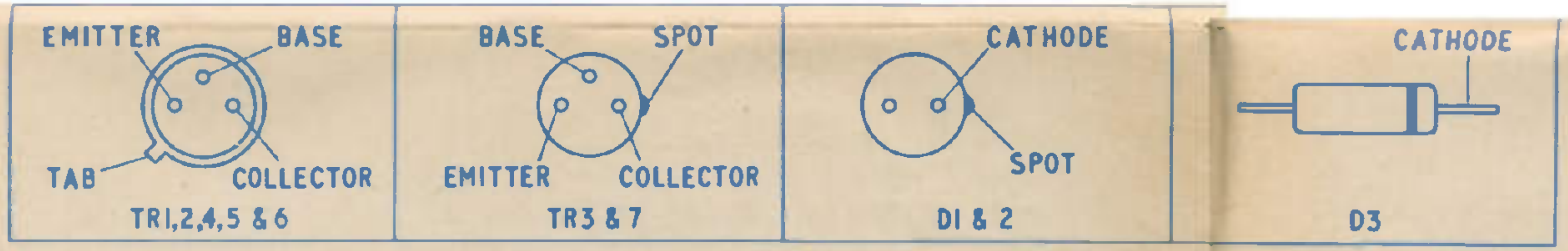

FIG. 6 — KEY TO TRANSISTOR AND DIODE CONNECTIONS

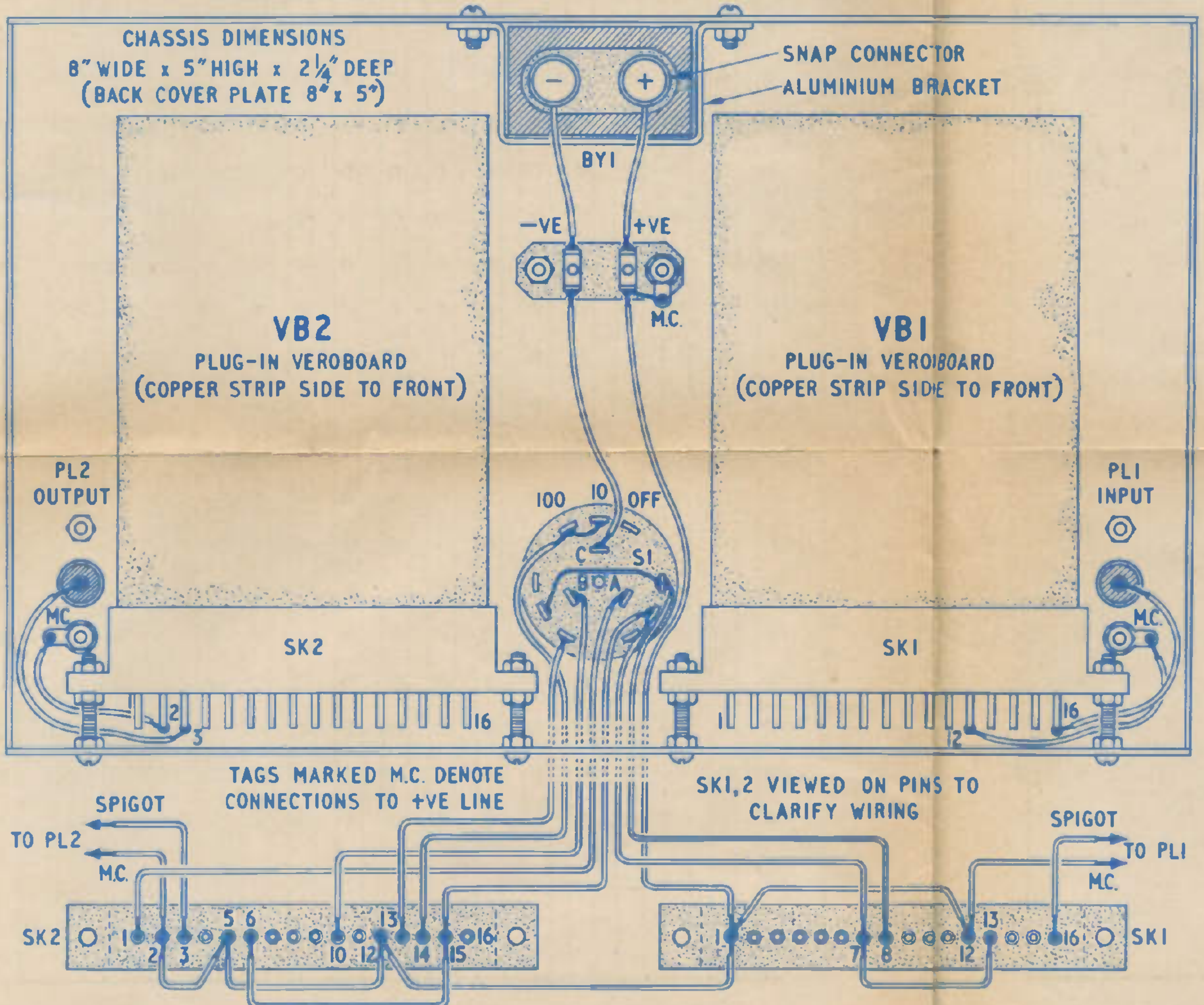

FIG. 7 — CHASSIS LAYOUT AND INTERBOARD WIRING

COMPONENTS LIST

Resistors

R1	4·7MΩ	R9	470Ω 1W 5%	R17	4·7kΩ
R2	27kΩ	R10	2·2kΩ	R18	4·7kΩ
R3	100kΩ	R11	820Ω	R19	680Ω 1W 5%
R4	470kΩ	R12	470Ω	R20	2·2kΩ
R5	4·7kΩ	R13	100kΩ	R21	270Ω
R6	27kΩ	R14	470kΩ	R22	2·2kΩ
R7	4·7kΩ	R15	4·7kΩ	R23	1MΩ
R8	4·7kΩ	R16	27kΩ		

All carbon ½W ± 10% unless otherwise stated

Potentiometers

VR1	500kΩ ± 20%
VR2	10kΩ ± 5%
VR3	500kΩ + 20%
VR4	10kΩ + 5%

All miniature carbon, preset, linear

Capacitors

C1	0·5μF paper	C5	500μF elect. 6V
C2	500μF elect. 6V	C6	10μF elect. 12V
C3	500μF elect. 12V	C7	100μF elect. 12V
C4	2·5μF elect. 12V		

Diodes and Transistors

D1	Z86·8	7V Zener diode	Brush Crystal Co;
D2	ZB6·8	7V Zener diode	
D3	ZFB6·2	6V Zener diode	

TR1	OC443	silicon
TR2	OC443	silicon
TR3	OC303	germanium
TR4	OC443	silicon
TR5	OC443	silicon
TR6	OC303	germanium
TR7	OC303	germanium

Miscellaneous

BY1	9V battery Ever Ready PP9 or equivalent, and connector
PL1	Coaxial socket, chassis mounting
PL2	Coaxial socket, chassis mounting
S1	Rotary switch 3 pole, 3 way and pointer knob
SK1	Chassis mounting socket for VB1 (VB3086)
SK2	Chassis mounting socket for VB2 (VB3086)
VB1	Veroboard. Plug-in type, 16 conductor strips, 21 holes per strip, 0·15in hole spacing, 2·5in wide, 3·8in long. Gold-plated plug-in conductor-strip ends (VB2503)
VB2	As VB1
	Hand awl for separating conductor strips into sections (VB3011)
	Suitable aluminium case, measuring approximately 5in × 8in × 2½in deep, with lid

DEC 64

QUALITY TAPE RECORDER
MT 1000 or TC 601. Fully Transistorised, Self-contained, Economical, Loudspeaker, Playback, Eraser, etc. **£8.19.6.**

PROFESSIONAL RECORDER
TP 703, Six Transistor, Capstan Drive, Two Speeds, Dual Track, Push-button Controls, Tape, Ideal Speech and Music, Many Refinements, **£16.16.0.**

INTERCOM OR BABY ALARM
Fully Transistorised, Low Running Cost, Super Performance, absolutely complete, **£3.19.6.**

TELEPHONE AMPLIFIER
TA790. Loudspeaker Speech by Transistor Amplifier with Magnetic Pick-up, only **59/6**

MULTIWAY INTERCOM SYSTEM
IP-7. Completely Transistorised Master Unit with Extension Indicators, Selector Switches, Volume Control, Completely Self-contained, Takes up to Six Extension Units, **14 Guineas.**

EXTENSION UNITS
2 Guineas each.

COMMUNICATION RECEIVER
RX. 60. 10-550 m. Continuous in Four Bands, S meter, Noise Limiter, Band Spread, B.F.O., 5" Speaker, etc., Three Aerials supplied giving professional reception, Quality Finish, **£24.15.0.**

PROFESSIONAL COMMUNICATION RECEIVER
RX 80. Double Superhet, Five Wave Band, Calibrated Electrical Band Spread on 80m, 40m, 20m, 15m, 10m Bands, S Meter, Q Amplifier, Aerial Trimmer, etc., **£45.0.0.**

12 VOLT 20 WATT P.A. AMPLIFIER
CA512. Ideal Street Broadcasting, Sports Events, Small Size, Terrific Performance, 4Ω, 8Ω, 16Ω, Output. 3 Inputs. **£22.**

10 WATT P.A. SPEAKERS
Compact Horn, High Efficiency, ideal for CA512 Amplifier. **£5.5.0.**

8-WATT STEREO AMPLIFIER
SA.80. Frequency Response 60-15,000 ±1db, Sensitivity 100 mV Stereo-Mono-Tuner-Phono, completely enclosed Gold/Black Quality Case, **£9.10.0.**

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SA. 300. Superb Reproduction, Gold enclosed finish, Many features including Hum Balance, Speaker Phasing, Rumble Filter, Integrated Tone Controls, Five Inputs, Selector Switch, Function Switch, 4, 8 and 16 ohm Outputs, Fantastic Value, **£29.10.0.**

40-WATT TRANSISTOR STEREO AMPLIFIER
TSA. 218. Five Separate Inputs, Rumble Filter Scratch Filter, 18 Transistors, 115-240 VAC, Loudness Switch, Mode Switch, Input Selector, Bass-Treble Balance Volume Controls, Superb Quality, Years of Trouble-free Use, **£49.10.0.**

HIFI FM TUNER
FMT. 040. Matches above Amplifiers, Sensitive 8-valve Circuit, Superb Styling, A.F.C. Built-in Power Pack, Individually factory aligned, **19 Guineas** (+64/- P.T.).

LOUDSPEAKERS
DUAL CONE 8"
6-Watt, 50-16,000 C.P.S., 16 ohms, Total Flux 53,000, **67/3.**

CR.12.AE. 12"
Twin Cone Peak Power 20-Watts, 16 ohms, **7 Guineas.**

CR.30.AE.12"
Three-way Speaker, Woofer made Range Radiator and Tweeter all within single speaker system, Phenomenal Realism, 16 ohms, **9 Guineas.**

12" Ultra Linear Speaker, Peak 25-Watts, 86 ohms, Total Flxx 200,000, Unbelievable performance, **12 Guineas.**

SLIM AUDIO PANEL 601 SPEAKER SYSTEM
A Built-in Crossover Network, Amazingly Realistic Performance, Superbly Finished Walnut Cabinet 21¼" × 17½" × 4¼", Response 50-18,000 C.P.S. 10-Watts, 16 ohms, **15 Guineas** (+50/6 P.T.).

AP.801. As above, but 20-Watts, 40-20,000 C.P.S., Size 29" × 21" × 4¼", **21 Guineas** (+ 70/9 P.T.).

HORN TWEETER CT10
10-Watts, 15-18,000 C.P.S., 16 ohms, High Sensitivity, Amazing Value **27/6.**

HT.20. 20-Watts, Rectangular Heavy Cast Finish, 16 ohms, **69/6.**

MM-4 FOUR CHANNEL MICROPHONE MIXER
Ultra Compact, Fully Transistorised, Gain 6 db, Gold Finish, Four Volume Controls, Uses 9-V Battery, **49/6.**

MICROPHONES
MM-71. Crystal, Compact Finish, screened lead, jack plug, **12/6.**

100 C. Three-Way Crystal "Stick" mic., Professional Finish, Built In/Off Switch, Detachable Shielded Cable, Neck Cord, Chrome Finish, **32/6.** MS 100 Desk Stand to match, **8/-.**

DM614. Miniature Stick Dynamic Mike with Stand and Neck Cord, **32/6.**

MC. 70. Studio Crystal mic., 360° Pick-up includes Sensitive Variable "D" Cartridge, Complete Shielded Cable, Swivel Mounting, **52/6.**

DM.14.S. Miniature Dynamic mic. with Stand, Crackle Chrome Finish, **62/6.**

DM. 11. Dynamic mic. with Base, 360° Swivel, 60-12,000 C.P.S., Superb Mist Blue Finish, **5 Guineas.**

DM.16.HL. Dual Impedance Dynamic Striking Design, Outstanding Performance, Self-Adjusting Swivel Action, 40-15,000 C.P.S., 50 ohms Low, 50K High, **£4.9.6.**

DM.17.HL. As DM.16.HL. but Directional Heavy Chrome Stick, On/Off Switch, Stand Adaptor, **£4.2.6.**

MICROPHONE STANDS
MS.100 Desk Stand, Grey Base with Short Chrome Stick, Standard Fitting, **8/-.**

DS.2. Heavy Duty Desk Stand, **29/6.**

FS.3. Floor Stand, Heavy Duty Variable Height, Cast Iron Base, Takes Standard Microphones, **£2.17.6.**

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PP. 190. Adjusted Arm Rest, Mono/Stereo Quality Turnover Cartridge, Magnetic Stylus Pressure, Professional Finish, **39/6.**

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EP.10.K. 10,000 OPV, High Quality, 15 Ranges AC/DC/Current/Resistance, Accuracy + or — 3%, **£3.19.6.**

EP.20.K. 20,000 OPV, more sensitive version of EP.10.K., **£4.19.6.**

EP.30.K. 30,000 OPV, 18 Ranges including Resistance to 10 meg., **£6.19.6.**

EP.50.K. Professional Quality, 22 Ranges, AC / DC / Volts / Current / Response / Decibels/Capacitance, **£9.19.6.**

TEST EQUIPMENT
1T1-1 Transistorised Signal Injector, Complete with Transistor Oscillator with Indicator Lamp, Detachable Test Probe and instructions, **35/-.**

RF Field Indicator RF.40. Tunes 1-250 Mc/S in Five Calibrated Bands with Telescopic, Aerial Earphone and UA Meter, **69/6.**

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HIGHEST QUALITY—COMPARE OUR PRICES

Carr. & Ins. 12/6. MOST MULLARD, EMITRON, EMI-SCOPE, BRIMAR, MAZDA, COSSOR, FERRANTI TYPES	GUARANTEED		NEW TYPES
	6 Months	**12 Months**	
12 in.	£1.15.0	£3.10.0	MW 31/74 £4-0-0
14 in.	£2. 0.0	£4. 0.0	NW 36/24 £5-0-0
15/17 in.	£2.15.0	£4.15.0	CRM 173 MW 43/64 £6-0-0
21 in.	£3.15.0	£5.15.0	

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100 CONDENSERS 10/-
Miniature Ceramic and Silver Mica.

SPECIAL TEMPORARY OFFER

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Guaranteed performance. Top Make. Tested 250V working.

100mA (3 for 9/6) **3/9**   500mA (3 for 19/6) **7/6**

4 watt AMPLIFIER
excellent amplifier with high gain preamp stage, 10F3 driving 10P14 output stage, complete with 8in. speaker. In attractive 2-tone case, Tone control, negative feedback, ready for immediate use, individually tested. Amazing volume and clarity, ideal for guitars, record players, p.a. in small halls, baby alarms, etc. Easily worth £5. Our price while stocks last. **47/6**
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General Purpose miniature detector (or 6/6 doz.) **8d.**
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Excellent Quality, Guaranteed Upright mounting 250-0-250V 60mA, 6.3V 3A **9/6**
Ditto semishrouded 9/6. Ditto upright 80 mA 12/6

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ALL VALVES ARE NEW UNLESS OTHERWISE INFORMED.

FREE TRANSIT INSURANCE. POSTAGE 1 valve 6d., 2-11 1/-; FREE OVER 12.

0Z4	4/6	6K8GT	8/3	14S7	14/6	EBC41	6/3	EZ41	5/9	R19	9/6
1A7GT	9/6	6K25	8/6	19AQ5	7/9	EBC81	5/9	EZ80	5/9	SP41	2/3
1C5GT	7/6	6L1	9/6	20D1	8/9	EBF80	7/6	EZ81	6/-	SP61	2/-
IH5GT	8/9	6L6	7/6	20F2	9/6	EBF89	7/9	FC4	8/-	T41	6/9
1N5GT	8/9	6L6G	6/6	20L1	16/-	EBL21	9/9	GZ32	7/6	TDD4	7/-
1S4	7/6	6L18	7/9	20P1	9/6	EBL31	19/6	HVR2	9/-	U14	7/6
2D21	5/6	6L19	12/6	20P3	11/-	EC52	4/9	KT33C	3/9	U18	7/6
3A4	4/-	6LD20	7/9	20P4	17/-	ECC32	4/-	KT36	14/-	U22	6/9
3A5	6/-	6P25	8/6	25A6G	8/-	ECC34	9/-	KT44	6/-	U24	12/6
3D6	4/-	6P28	9/9	25L6GT	7/9	ECC40	6/9	KT45	8/6	U25	9/3
3Q4	5/-	6Q7G	4/-	25Z4G	7/-	ECC81	4/9	KT61	8/6	U26	7/-
5R4GY	8/-	6Q7GT	8/-	30F5	6/-	ECC82	4/9	KT73	5/9	U35	12/6
5U4G	4/-	6SA7	5/9	30FL1	9/6	ECC83	5/9	KT66	12/-	U50	4/6
5Y3G	4/6	6SG7	4/9	30L15	8/9	ECC84	7/6	KT76	8/6	U107	12/6
5Y3GT	4/-	6SK7	5/-	30P4	9/6	ECC85	6/-	KT88	17/6	U191	9/-
5Z4	9/-	6SL7GT	5/6	30P12	7/-	ECC88	9/6	KTW61	5/9	U281	8/6
5Z4G	7/-	6SN7GT	4/6	30PL1	9/3	ECF80	6/-	KTW63	5/-	U282	15/-
5Z4GT	9/6	6SQ7	5/9	35C5	8/6	ECF82	8/3	KTZ63	7/-	U301	12/6
6/30L2	9/-	6U4GT	8/-	35L6GT	8/-	ECH21	11/6	MU14	7/-	U329	8/6
6A8G	7/9	6V6G	4/6	35W4	6/-	ECH35	7/6	N37	10/6	U801	19/-
6AG7	7/6	6V6GT	6/-	35Z4GT	5/6	ECH42	8/6	N78	13/-	UABC80	7/-
6AK5	4/3	6X4	4/6	50L6GT	8/6	ECH81	7/-	N108	13/-	UAF42	7/9
6AQ5	5/-	6X5G	5/-	80	5/-	ECH83	6/3	PC86	10/-	UB41	6/6
6AT6	5/-	6X5GT	5/6	185BT	19/6	ECL80	6/6	PC97	7/6	UBC41	7/6
6AU6	7/-	7B6	9/-	185BTA	19/6	ECL82	8/-	PCC84	6/6	UBC81	6/-
6AV6	6/-	7B7	5/6	807(A)	5/-	ECL83	10/6	PCC85	6/6	UBF80	7/9
6BA6	5/6	7C5	7/3	807E	4/9	ECL86	10/3	PCC88	11/9	UBF89	7/6
6BE6	5/6	7C6	7/6	813	49/-	EF36	3/-	PCC89	8/6	UBL21	9/6
6BG6G	15/-	7H7	5/-	866A	12/6	EF39	4/6	PCC189	13/6	UCC85	7/3
6BH6	5/-	7S7	8/9	954	3/6	EF40	11/-	PCF80	6/9	UCF80	8/6
6BJ6	5/-	7Y4	4/6	955	2/3	EF41	8/-	PCF82	6/-	UCH21	9/3
6BR7	8/6	10C1	9/-	956	2/-	EF54	3/3	PCF84	12/-	UCH42	7/3
6BW6	6/9	10C2	14/6	9001	3/6	EF80	3/6	PCF86	7/6	UCH81	7/9
6BW7	5/-	10F1	4/9	9002	4/9	EF85	6/-	PCL82	7/9	UCL82	8/-
6C4	2/3	10LD11	14/6	9003	5/6	EF86	7/6	PCL83	9/-	UCL83	10/-
6C5	5/6	10P13	8/6	ATP4	2/6	EF89	6/9	PCL84	7/3	UF41	6/6
6C6	5/6	10P14	9/6	AZ31	6/-	EF91	3/-	PCL85	7/6	UF42	4/9
6C9	11/-	12AH7	7/-	B36	4/6	EF92	3/-	PCL86	10/6	UF80	6/3
6CD6G	17/-	12AH8	9/-	CBL31	19/-	EF183	9/9	PEN25	3/9	UF85	7/6
6D6	3/-	12AT6	6/6	CL33	9/-	EF184	9/6	PEN45	8/6	UF89	5/9
6F1	4/9	12AT7	4/9	CY31	7/6	EL32	3/9	PEN46	4/6	UL41	7/6
6F6G	3/6	12AU6	9/-	DAF91	4/6	EL33	6/6	PL33	8/6	UL44	14/-
6F13	4/3	12AU7	4/9	DAF96	7/3	EL34	11/6	PL36	9/6	UL46	8/3
6F14	9/6	12AV6	6/3	DF91	3/-	EL35	6/-	PL38	17/6	UL84	7/-
6F15	9/6	12AX7	6/-	DF92	3/-	EL38	12/6	PL81	7/9	UR1C	7/6
6F23	6/6	12BA6	7/-	DF96	7/3	EL41	8/-	PL82	6/6	UM80	9/6
6J5G	3/-	12BE6	6/6	DK91	5/6	EL42	7/9	PL83	6/6	UU6	8/9
6J5GT	4/3	12BH7	8/9	DK92	7/-	EL84	6/6	PL84	7/6	UU8	11/-
6J6	2/6	12E1	17/6	DK96	7/3	EM34	8/6	PY31	8/-	UY21	9/6
6J7G	4/9	12J7GT	8/-	DL92	5/-	EM80	7/9	PY32	10/-	UY41	6/-
6J7G7	7/6	12K7GT	4/-	DL94	6/6	EM81	6/9	PY80	6/6	UY85	5/-
6K6GT	6/-	12K8	9/9	DL96	7/3	EM84	8/9	PY81	5/9	VR105	5/6
6K7	5/9	12K8GT	9/6	EABC80	6/6	EM85	8/6	PY82	5/9	VR150	5/-
6K7G	1/-	12Q7GT	5/-	EAF42	3/3	EY51	7/6	PY83	5/9	X66	7/9
6K7GT	4/6	12SA7	6/3	EB41	5/-	EY86	7/3	PY88	9/-	6	6/-
6KS	8/6	12SK7	2/9	EB91	2/-	EY88	8/6	PY800	6/3	Z66	8/6
6K8G	5/-	12SQ7	7/6	EBC33	4/9	EZ40	6/6	PZ30	9/6		

Post: 2 lbs. 2/-, 4 lbs. 2/6, 7 lbs. 3/6, 15 lbs. 4/-, etc. (C.O.D. 2/- extra). ALL ITEMS LESS 5% AND POST FREE IN DOZENS.

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Amplifier
by

Be first to own the only amplifier of its kind in the world

10 WAT OUTPUT

NO HEAT SINK

1mV INPUT SENSITIVITY

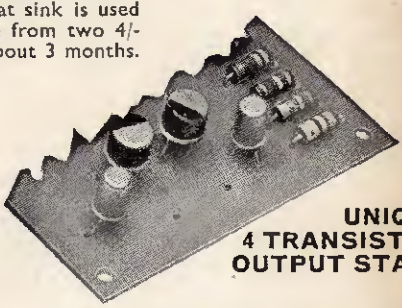
GIVES FANTASTICALLY GOOD REPRODUCTION

THE SINCLAIR X-10 is a high fidelity integrated power amplifier and pre-amp using 11 transistors and having a transformerless output of 10 watts for feeding into a 15 ohm loudspeaker system. It requires only the addition of tone and volume controls plus a twelve volt D.C. power supply to make it a complete mono high fidelity assembly of exceptional quality. Stereo is achieved by using two X-10 amplifiers and ganged or separate controls. Input sensitivity is sufficient for all crystal or magnetic pick-ups and the manual supplied with the X-10 gives detailed instructions for connecting the controls and for using the amplifier in a wide variety of applications.

This radically new transistor amplifier (patents applied for) is the first to be marketed anywhere in the world using the Pulse Width Modulation principle (P.W.M.).

This technique permits an enormous reduction in the power dissipation in the output transistors of an amplifier; and in the case of the Sinclair X-10, the output efficiency is about 95% as compared with about 60% for conventional class B output stages. Thus the dissipation is only $\frac{1}{8}$th or less of that occurring in all other amplifiers. That is why no heat sink is used and why the X-10 will operate from two 4/- batteries with normal use for about 3 months.

NEW *DESIGN PRINCIPLES PERFORMANCE* !



UNIQUE 4 TRANSISTOR OUTPUT STAGE

Another Sinclair special feature—these 4 transistors do not get hot even at full output because the circuit converts almost 100% of the power from battery or mains unit into audio power for the loudspeaker.

- ★ **Number of transistors 11**
- ★ **Overall size** 6" x 3" x $\frac{3}{4}$"
- ★ **Input Sensitivity** 1mV
- ★ **Total harmonic distortion** < 0·1%
- ★ **Output power** 10 watts
- ★ **Frequency response** 5-20,000 c/s ± 0·5dB
- ★ **Speaker impedance** 15Ω
- ★ **Damping factor** Greater than 100
- ★ **Quiescent consumption** 75mA
- ★ **Supply voltage** 12 to 15 volts

SINCLAIR X-10

COMBINED 10 WATT AMPLIFIER & PRE-AMP

Guarantee

If you are not completely satisfied with your purchase (we are confident you will be delighted) your full purchase price will be refunded instantly and without question.

FULL SERVICE FACILITIES ALWAYS AVAILABLE TO SINCLAIR CUSTOMERS

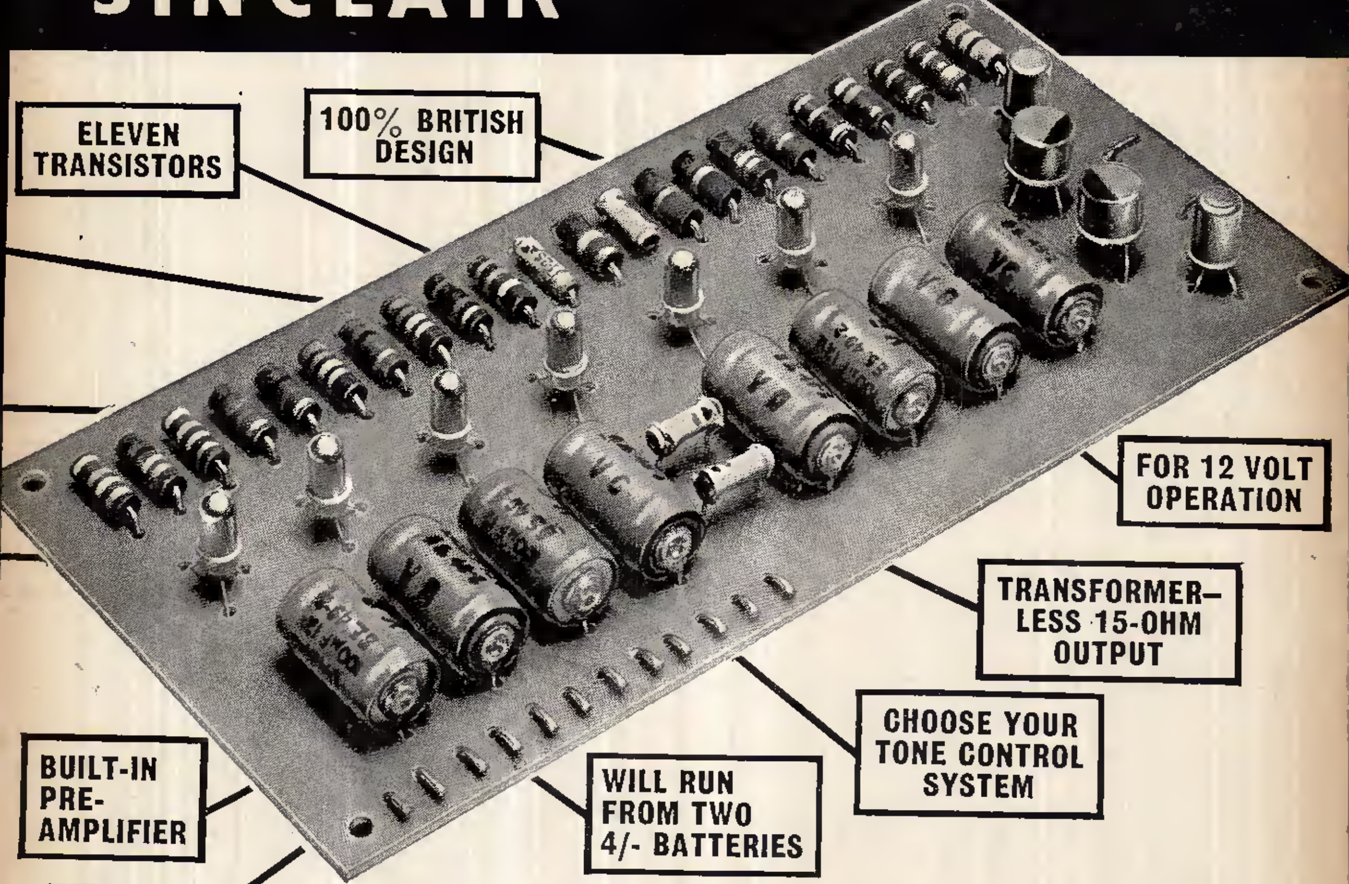
Build it for
£5-19-6
inclusive of all parts and instructions manual

READY BUILT AND TESTED
£6-19-6
Including instructions manual

ANOTHER WINNING DESIGN FROM **SINCLAIR RADIONIC**

Breakthrough

SINCLAIR



ELEVEN TRANSISTORS

100% BRITISH DESIGN

FOR 12 VOLT OPERATION

TRANSFORMER-LESS 15-OHM OUTPUT

CHOOSE YOUR TONE CONTROL SYSTEM

WILL RUN FROM TWO 4/- BATTERIES

BUILT-IN PRE-AMPLIFIER

SIZE 6″ x 3″

PWM *is the answer!*

THE SINCLAIR X-10 is the only amplifier in the world to give you the unique benefits of Pulse Width Modulation. Briefly, with this system, the audio signal from pick-up, radio, microphone or tape head modulates a high-frequency square wave "carrier" by varying the mark-space ratio. These variations are converted to energy in the output stage. Being independent of the transfer characteristics of the output transistors, the output is an exact replica of the input signal. The improvement in the quality of reproduction from the loudspeaker is instantly apparent. Transient response is much clearer, there is no falling off in the higher audio-frequencies, no intermodulation distortion and the response curve so flat you could draw it with a ruler! A new type of output stage and P.W.M. plus many other circuit refinements result in an amplifier which is compact, rugged, stable and does not require a heat sink—and it costs so little. The X-10 may be used with low-input pick-ups such as Decca Deram, Ortofon, etc., as well as with tape playback heads. Used in pairs the X-10 brings new depths to stereo listening and there are no channel matching problems.

SINCLAIR X-10 MANUAL

supplied with every every X-10, built or in parts, this 12 page manual explains how the amplifier functions and how you can add the correct tone and volume control system to suit your requirements exactly. A variety of systems is shown for mono and stereo use, none of which will add more than a few shillings to the original cost of your Sinclair X-10 amplifiers.

FREE WITH AMPLIFIER. AVAILABLE SEPARATELY, PRICE 1/-.

MAINS POWER SUPPLY UNIT
(A.C. 200/240V)
£2-14-0

*
Order form and further Sinclair designs on next pages

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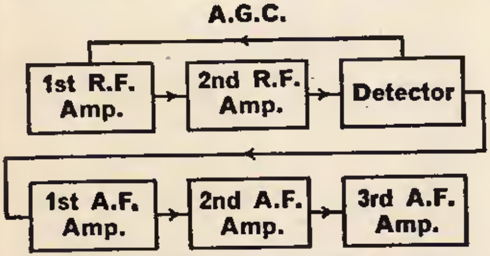
Micro-

GUARANTEED DESIGNS FOR THE CONSTRUCTOR

It's easy to build the SMALLEST RADIO IN THE WORLD

THE SINCLAIR MICRO-6 is an entirely British design which remains unchallenged as the most remarkable receiver of its kind ever made available to the public anywhere in the world. It has special 6-stage circuitry and is, at the same time, the smallest set on earth. Everything except the lightweight earpiece is contained in the smart, minute white, gold and black case which is appreciably smaller than a matchbox, as the illustration shows. With vernier-type tuning control, bandspread over the higher frequency end of the medium waveband and powerful A.G.C. to ensure fade-free reception of the most distant stations, the Micro-6 provides remarkable standards of performance. Quality of reproduction is outstandingly good and, again and again, the set is reported to give excellent results where other sets cannot be used at all. The Micro-6 cannot be too highly recommended, both as an intriguing design to build, and a most practical radio to use. Over 9,000 have been built and are in daily use throughout the world.



BLOCK DIAGRAM OF SINCLAIR MICRO-6

SIX-STAGE POWER AND SELECTIVITY

The Micro-6 uses special Sinclair Micro-Alloy Transistors in a completely new circuit. Two stages of R.F. amplification are followed by an efficient double diode detector which drives a high-gain 3-stage A.F. amplifier. Powerful A.G.C. applied to the first R.F. stage ensures fade-free reception from the most distant stations tuned in. Everything including micro-components never before made available to home constructors, special ferrite-rod aerial and 2 batteries each smaller than an aspirin tablet and giving about 70 hours working life is contained within the elegant tiny case.

ACTUAL SIZE

SINCLAIR MICRO-6

SIX-STAGE POCKET RECEIVER

Build it in an evening!

Building is simple and straightforward when the meticulously detailed instructions are followed. All parts including **MAT** transistors, diodes, printed circuit board, lightweight earpiece, case and dial, and 8-page instruction manual come to **59/6**

'TRANSRISTA' black nylon wrist strap for wearing the Micro-6 like a wrist watch (*see illustration opposite*) **7/6**

MALLORY MERCURY CELL ZM312 (*two required*) each **1/11** Special pack of 6 **10/6**

- **SIZE** 1$\frac{4}{5}$″ × 1$\frac{3}{10}$″ × $\frac{1}{2}$″
- **WEIGHT** Less than 1 oz. (with batteries)
- Tunes over medium wave band
- Bandspread over higher frequency and brings in Luxembourg like a local station
- Vernier-type tuning
- Plays in car, train, bus, plane, etc.
- Brings in Continental as well as B.B.C. stations
- Can be used as a radio-jack for tape-recorders
- Wonderful quality, tone and volume

Full service facilities available to all Sinclair customers

sinclair

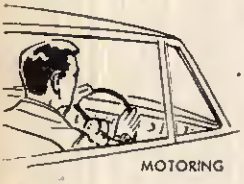
SINCLAIR RADIONICS LTD., COMBERTON, CAMBRIDGE
Telephone: COMBERTON 682

Masterpieces

FROM BRITAIN'S LEADING TRANSISTOR SPECIALISTS

WEAR IT LIKE A WRIST WATCH

A novel and convenient way to use the Micro-6 is to fix it on to the 'Transrista' Wrist Strap and wear it like a watch. Particularly useful for sportsmen, travellers, etc.

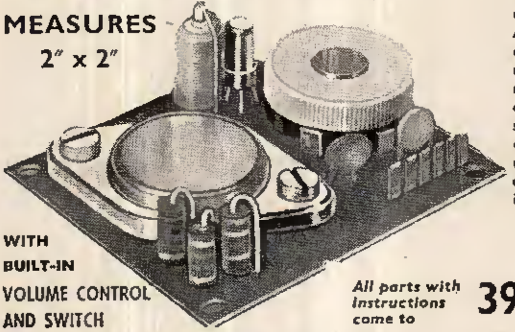


SINCLAIR TR750 POWER AMPLIFIER

Designed specially for use with the Micro-6 and Slimline Receivers

★ **MAKES A CAR RADIO, DOMESTIC RADIO, PORTABLE, INTERCOM, Etc.**

MEASURES 2" x 2"



WITH BUILT-IN VOLUME CONTROL AND SWITCH

Measures only 2in. x 2in. yet includes its own volume control and switch. It will provide powerful loudspeaker reproduction from the Micro-6 or Slimline which can then be used as a car radio, or domestic or portable loudspeaker set. A plug is supplied for connecting to either Sinclair set. The TR750 also has many other applications such as record reproducer, intercom or baby alarm. An output of 750 milliwatts for feeding into a standard 25-30Ω loudspeaker requires only a 10mV input into 2KΩ. Frequency response 30-20,000 c/s ± 1dB. Power required 9 to 12 volts. Assembling and installing is very easy.

ANOTHER OUTSTANDINGLY SUCCESSFUL SINCLAIR DESIGN.

All parts with instructions come to **39/6**

READY BUILT AND TESTED with instructions **45/-**

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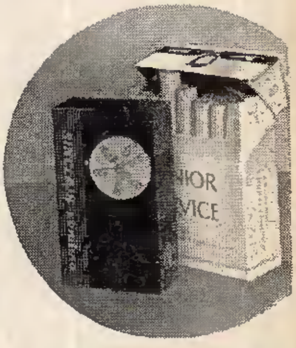
Post your order today

SINCLAIR SLIMLINE

The extra-easy-to-build 4-stage pocket receiver



Particularly recommended for newcomers to transistor set building. Measures 2$\frac{11}{16}$" x 1$\frac{11}{16}$" x $\frac{1}{2}$". Everything is contained within the gold-trimmed royal blue case, including standard PP.5 battery and ferrite-rod aerial. Uses vernier-type tuning to cover the medium waveband with reception of many British and Continental stations. Listening is by means of the featherweight earpiece which switches the set on when plugged in. The building instructions make success assured, even if you have never built a set in your life. Operates from a standard PP5 battery, obtainable anywhere.

All parts inc. case, transistors, earpiece and instructions come to **49/6**

If you do not wish to cut the coupon from this page, please mention "Practical Electronics," December, when ordering

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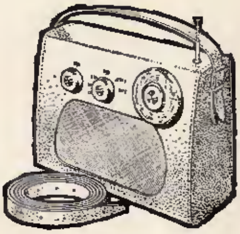


ROAMER SEVEN Mk III

5 WAVEBAND PORTABLE OR CAR RADIO

Amazing performance and specification ★ ***Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS***

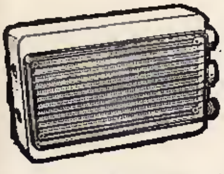
● 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves, Trawler Band and two Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned heavy duty 5in. speaker. Air spaced ganged tuning condenser. Ferrite rod aerial for M & L Waves and telescopic aerial for S Waves. Real leather-look case with gilt trim and shoulder and hand straps. Size 9 × 7 × 4in. approx. The perfect portable and the ideal car radio. (Uses PP7 battery available anywhere).

Total cost of parts now only **£5.19.6** P. & P. 5/6

Parts Price List and easy build plans 3/-

TRANSONA FIVE



Home, Light, A.F.N., Lux. all at good volume.
G.P. Durham

●7 stages—5 transistors and 2 diodes

Fully tunable over Medium and Long Waves and Trawler Band. Incorporates Ferrite rod aerial, tuning condenser, volume control, new type fine tone super dynamic 2¾in. speaker, etc. Attractive case. Size 6½ × 4½ × 1¼in. with red speaker grille. (Uses 1289 battery available anywhere.)

Total cost of all parts now only **42/6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

COMPONENT BARGAINS ALL POST FREE

TRANSISTORS

PHILCO MADT Type 2N1727 Maximum frequency of oscillation 150 Mc/s .. .. 8/6.

PHILCO MADT Type 2N1728 Maximum frequency of oscillation 150 Mc/s ... .. 9/6.

PHILCO MADT (Micro Alloy Diffused) Type 2N503 Maximum frequency of oscillation over 500 Mc/s 15/-

Diodes 1/6

Standard interleaved output transformers for valve output stages 3/6

SWITCHES

Slide, single pole, heavy springs 2/3

Yaxley 6-way, 2 pole .. 4/9

TUNING CONDENSERS

Air spaced fine quality German manufacture with slow motion drive. 0·0005 with oscillator section 9/6

Subminiature similar 00 with tuning and oscillator sections 7/6

Subminiature mica dielectric with trimmers. Tuning 200 pf, Oscillator 50 pf .. 5/6

Mica dielectric 0·0003 mfd, 3/10

BELLPHONES

Ex-G P.O. Suitable as sound powered telephones. Resistance of coil 60 ohms approx. 3in. U-shaped magnet .. 5/9

HEADPHONES

High fidelity miniature magnetic earpieces (2) on slim band with lead and plug. Easily converted to stereo. American manufacture 13/6

Miniature crystal earpiece with lead plug and socket 6/6

DIALS AND KNOBS

3in. dial with polished brass insert and M/L calibrated disc 6/6

1in. cream knobs with polished brass insert and rim 1/3 each

CASES

Real leather-look cases in chestnut shade with holes punched for tuning, volume control and switch. Also holes punched for car aerial socket and tone control. 9½ × 3½ × 7½in. approx. Complete with carrying straps 35/-

Plastic cases in grey polystyrene with red ornamental grille, 6½ × 4½ × 1½in. approx. 6/9

Telescopic aerials with fixing socket 6/6

SUPER SEVEN

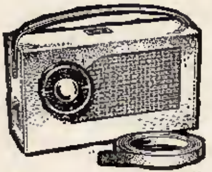
● 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves and Trawler Band. The ideal radio for home, car, or can be fitted with carrying strap for outdoor use. Completely portable—has built-in Ferrite rod aerial for wonderful reception. Special circuit incorporating 2 RF Stages, push-pull output, 3in. speaker (will drive large speaker). Size 7½ × 5½ × 1¼in. (Uses 9v battery, available anywhere.)

Total cost of all parts now only **£3.19.6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

MELODY SIX

". . . amazed at volume and performance, has really come up to my expectations".
S.G., Stockton-on-Tees.



● 8 stages—6 transistors and 2 diodes

Our latest completely portable transistor radio covering Medium and Long Waves. Incorporates pre-tagged circuit board, 3in. heavy duty speaker, top grade transistors, volume control, tuning condenser, wave change slide switch, sensitive 6in. Ferrite rod aerial. Push-pull output. Wonderful reception of B.B.C. Home and Light, 208 and many Continental stations. Handsome leather-look pocket size case, only 6½ × 3½ × 1¾in. approx. with gilt speaker grille and supplied with hand and shoulder straps.

Parts Price List and easy build plans 2/- Total cost of all parts now only **£3.9.6** P. & P. 3/-

TRANSONA SIX

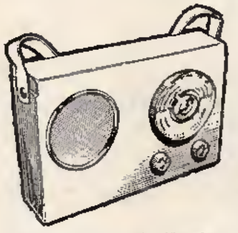
●8 stages—6 transistors and 2 diodes

This is a top performance receiver covering full Medium and Long Waves and Trawler Band. High-grade approx. 3in. speaker makes listening a pleasure. Push-pull transformers for ample power. Ferrite rod aerial. Many stations listed in one evening including Luxembourg loud and clear. Attractive case in grey with red grille. Size 6½ × 4½ × 1¼in. (Uses PP4 battery available anywhere.)

Total cost of all parts now only **59/6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

ROAMER SIX *NEW!!*

NOW WITH PHILCO MICRO-ALLOY R.F. TRANSISTORS



● 6 WAVEBAND!!

● 8 stages—6 transistors and 2 diodes

Listen to stations half a world away with this 6 waveband portable. Tuneable on Medium and Long Waves. Trawler band and three Short Waves. Sensitive Ferrite rod aerial and telescopic aerial for short waves. Top grade transistors. 3-inch speaker, handsome case with gilt fittings. Size 7½ × 5½ × 1¼in.

★ Extra band for easier tuning of LUX., etc.

Parts Price List and easy build plans 2/- Total cost of all parts now only **£3.19.6** P. & P. 3/6 (Carrying Strap 2/6 extra.)

All components used in our receivers may be purchased separately if desired. Parts price lists and easy build plans supplied free with sets of parts or available separately at fixed prices stated.

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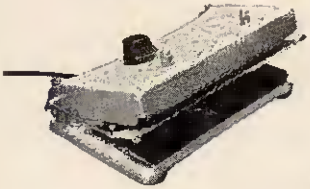

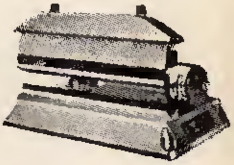

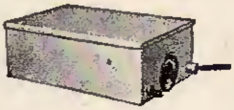

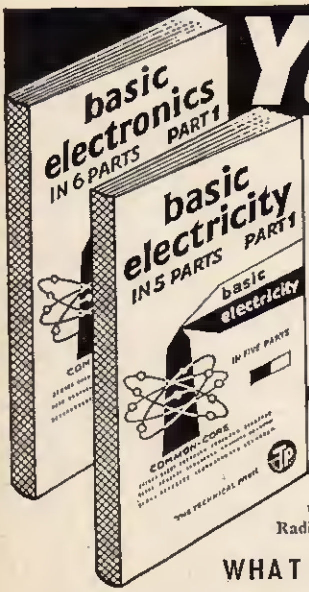
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TAPE AMPLIFIER FOR STUDIO DECK, with ready wired printed circuit, control and input panels, mains and output transformers, knobs, plans, screws etc.: EF86, ECC83, EZ80, EM85 and 2 EL84. 3 watts output. Magic eye, Radio & Mic. inputs, ext. speaker socket, tone and monitor controls. Can be used as an amplifier	£11.11.0	47/-	8	25/6
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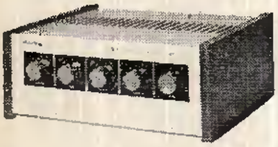
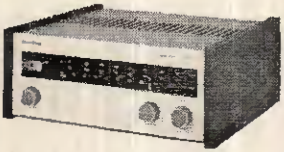
ARMSTRONG AMPLIFIERS AND TUNERS


MODEL 222


MODEL 223

222 Integrated Stereo Amplifier 10 + 10 watt..	£27.10.0	110/-	12	40/4
223 A.M.-F.M. Tuner	£28.15.0	115/-	12	42/2
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127/M Mono Tuner/Amplifier 5 watt	£26.10.0	106/-	12	38/10
127 Stereo Tuner/Amplifier 5 + 5 watt	£37.10.0	150/-	12	55/-
227M Mono Tuner/Amplifier 10 watt	£36.15.0	147/-	12	53/-
227 Stereo Tuner/Amplifier 10 + 10 watt	£52.15.0	211/-	12	77/4
226 Stereo Tuner/Amplifier as 227 but with Mag. P.U.	£61.0.0	260/-	12	88/-
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Linear L 45/A, 3 valve, 3 watt.	£6.6.0			
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Leak Stereo 20, Pre-amplifier and Main amplifier complete	£55.9.0	229/-	12	80/8
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The new **Martin All Transistor Ten Watt Amplifier** kits represent excellent value for money. Each unit is complete, requiring only to be connected to the next. We show only the popular units here. Others available including stereo. The following would make up a **TRANSISTORISED AMPLIFIER 15 ohms MODEL**				
UNIT 1—FIVE INPUT SELECTOR. Size 3½ × 3in. Mag. PU, Crystal PU, Radio, Mic., Tape Head	£2.7.6	—	—	—
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Hi Fi LOUDSPEAKERS

W.B. HF812, 8in., 3.75, 7.5 and 15 ohms	£3.16.6	—	—	—
Goodmans Axiette, 8 in.	£5.5.7	—	—	—
Goodmans Axiom, 10 in.	£6.5.11	—	—	—
Goodmans 5K/20/XL, Tweeter and Crossover	£7.7.0	—	—	—
Goodmans 201, 12in. unit Full range 15 watt....	£10.17.6	43/6	8	24/3
W.B. HF1012, 12in., 3.75, 7.5 and 15 ohms...	£4.12.0	—	—	—
Goodmans X05000, £2.0.11., **X0950**	£5.10.11	—	—	—
Wharfedale Super 3, Tweeter	£5.16.8	—	—	—
Wharfedale Super 5, Tweeter	£5.19.7	—	—	—
Wharfedale Super 8 RS/DD, Full range unit...	£6.14.2	—	—	—
Wharfedale Super 10 RS/DD, Full range 10 unit	£10.18.0	44/-	8	24/3
Wharfedale Super 12 RS/DD	£17.10.0	70/-	12	25/8
Wharfedale RS/12/DD, 12in. unit Full range...	£11.10.0	46/-	8	25/6
Goodmans 301, 12in. unit Full range 20 watt...	£15.4.6	61/-	12	22/4

LEAFLETS AVAILABLE ON REQUEST

GRAMOPHONE UNITS

B.S.R. UA25, Very latest model	£6.6.0	—	—	—
B.S.R. UA14 with TC8 Mono cartridge	£6.19.6	28/-	6	22/-
Garrard SRP10 Single player, Mono cartridge	£5.10.0	—	—	—
Garrard Autoslim, 4 Speed changer Mono ...	£7.17.0	33/-	6	24/-
Garrard AT 5 P Improved Autoslim, Stereo	£9.0.0	36/-	6	27/4
Garrard A.T.6 Autoslim de Luxe, mono ...	£11.9.0	47/-	8	25/3
Garrard AT 5 3000LM as **AT6,** but with slim arm, stereo	£11.12.0	46/6	8	25/9
Garrard 4H/F, Transcription unit Mono	£17.0.0	68/-	12	24/11
Garrard "Deccadek" Single Player with Decca "Deram" cartridge	£15.15.0	63/-	12	23/1
Garrard LAB. "A", Transcription changer Mono	£19.14.9	79/-	12	28/11
Garrard 301 Strobe, Transcription unit	£22.0.0	88/-	12	32/3
Philips AG1016, Stereo cartridge, will change 7in. records with adaptor 10/- extra	£12.12.0	50/6	12	18/6
Goldring GL58, with arm but less cartridge...	£17.1.0	69/-	12	24/11
Goldring GL70, with arm but less cartridge......	£27.9.4	111/4	12	40/1
Goldring "88", Transcription less arm	£18.18.5	76/5	12	27/8

LEAFLETS ON REQUEST

GUITAR SPEAKERS

Fane, 12in. Heavy duty unit 20 watt	£5.5.0	—	—	—
Goodmans Audiom 51, 12in. 15 watt Bass	£9.2.8	36/8	6	27/8
Goodmans Audiom 61, 12in. 20 watt Bass or Lead	£14.7.8	57/8	12	21/1
Goodmans Audiom 81, 15in.	£25.0.0	100/-	12	36/8
Goodmans Audiom 91, 18in. 50 watt Bass	£29.15.0	119/-	12	43/7
Wharfedale W 12/EG, 12in. 15 watt Lead ...	£10.10.0	42/-	8	23/6
Wharfedale W 15/EG, 15in. 15 watt Bass ...	£17.10.0	70/-	12	25/8

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GUITAR AMPLIFIERS

Linear Diatonic 12 watt 2 inputs	£13.2.6	52/6	12	19/3
Linear Conchord 30 watt 2 inputs with Cover	£19.4.6	77/-	12	28/2
Leak TL·25 25 watts amp and pre-amp	£42.5.0	169/-	12	61/11
Leak TL 50 50 watts amp and pre-amp	£51.5.0	205/-	12	75/2

MICROPHONES AND FLOOR STANDS

Reslo RBH/T, Ribbon High Impedance	£11.2.6	44/6	8	24/9
Reslo RBH/TS, Ribbon with on/off switch ...	£13.10.0	54/-	12	19/9
Reslo Heavy Duty Floor Stand	£7.0.0	—	—	—
Teisco DM304, Dual Impedance with switch...	£4.10.0	—	—	—
Piezo BM3, Crystal with switch, desk stand ...	£2.10.0	—	—	—
Jap, Floor Stand	£3.3.0	—	—	—

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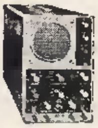
IO-12-U


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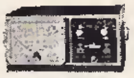
IM-13U


HFW-1

6 in. DE LUXE VALVE VOLTMETER, Model IM-13U. Measures ac and dc volts 0-1.5 to 1,500V in 7 ranges. Res. to 1,000 MΩ in 7 ranges. Modern styling, with gimbal mount. Kit **£18.18.0.** Assembled **£26.18.0.**

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UXR-2


RG-1

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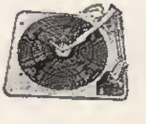
PA-1


AT-6

R.F. SIGNAL GENERATOR, Model RF-1U. Freq. coverage from 100 kc/s-100 Mc/s or six bands, on fundamentals and up to 200 Mc/s on calibrated harmonics. Kit £13.8.0. Assembled £19.18.0.

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saves wear on soldering iron bits

SAVBIT SIZE 1 CARTON

Contains approximately 30 feet of 18 s.w.g. SAVBIT. It is also supplied in 14 s.w.g. and 16 s.w.g. Obtainable from radio and electrical stores.

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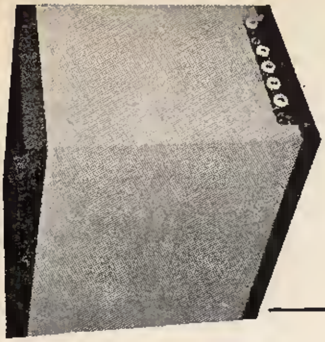

BASS-MAJOR 30 WATT GUITAR AMPLIFIER

A MULTI-PURPOSE HIGH FIDELITY, HIGH OUTPUT UNIT
FOR VOCAL AND INSTRUMENTALIST GROUPS

Eminently suitable for bass, lead or rhythm guitar and all other musical instruments

★ Incorporating two 12in. heavy duty 25-watt high flux (17,000 lines) loudspeakers with 2in. diameter speech coils. Designed for efficiently handling full output of amplifier at frequencies down to 25 c.p.s.
★ Dual Cone in second speaker reproduces frequencies up to 17,000 c.p.s.
★ Heavily made cabinet of convenient size 24 × 21 × 14in. has an exceptionally attractive covering in two contrasting tones of Vynair.
★ For 200-250 v., 50 c.p.s., A.C. mains operation.
★ Four jack socket inputs and two independent volume controls for simultaneous connection of up to four instrument pick-ups or microphones.
★ Separate bass and treble controls providing more than adequate "Boost" or "Cut".
★ LEVEL frequency response throughout the audible range.
★ SUPERIOR TO UNITS AT TWICE THE COST.

39½ Gns.

Send S.A.E. for leaflet OR DEPOSIT of £4.3.0 and 12 monthly payments of £3.9.11. Carr. 17/6.

R.S.C. G5 GUITAR AMPLIFIER

5-watt high quality output. Incorporating high flux 12in. 10 watt 12,000 line loudspeaker. Sensitivity 50 m.v. High impedance jack input. Handsome strongly made cabinet (size 14 × 14 × 7in. approx.) finished in complementary shades of Rexine/Tygan. 200-250 A.C. mains.

£9.19.6 Or DEPOSIT 22/3 and 9 monthly payments of 22/3. Carr. 7/6.

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Designed for introducing the Tremolo effect to any amplifier which is fitted with a reserve power supply point for smoothed H.T. and 6.3 v. A.C. L.T. This applies to practically all amplifiers of our manufacture, and to those of several other manufacturers. The unit plugs into power supply point and any input socket or amplifier. Controls are Speed (frequency of interruptions), Depth (for heavy or light effect), Volume and Switch. Three sockets are for two inputs and Foot Switch. ONLY **4 Gns.**

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HIGH FIDELITY AMPLIFIER A10

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11 Gns.
Carr. 10/-

TERMS: DEPOSIT 33/9 and 9 monthly payments of 33/9.
Suitable mikes & spkrs. available at competitive prices.

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12in. 15 ohms. Cast chassis. Exceptionally robust 2in. diam. Voice Coil Assemblies.

122/10 20 watt, **5** gns.	122/10A 20 watt, **6** gns.
122/12 20 watt, **7** gns.	122/12A 20 watt, **8** gns.
122/14 22 watt, **9** gns.	122/14A 22 watt, **10** gns.
122/17 25 watt, **£11.17.6**	122/17A 25 watt, **£12.17.6**

15in. 15 ohms. Cast chassis. Exceptionally robust 2in. diam. Voice Coil Assemblies.

152/12 20 watt, **12** gns.	152/12A 20 watt, **13** gns.
152/14 27 watt, **14** gns.	152/14A 27 watt, **15** gns.
152/17 35 watt, **16** gns.	152/17A 35 watt, **17** gns.

"A" indicates dual cone type. 30-17,000 c.p.s. Send S.A.E. for leaflets. Terms available.

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High-fidelity push-pull output. Separate bass and treble "cut" and "boost" controls. Twin separately controlled inputs so that two instruments or "mike" and pick-ups can be used at the same time. Loudspeaker is a heavy duty high flux 12in. 20 watt model with cast chassis. Cabinet is well made and finished as Junior Model. Size approx. 18 × 18 × 8in.

Only **19 Gns.** Carr. 10/-

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A highly efficient unit incorporating a massive 15in. high flux loudspeaker specially constructed to withstand heaviest load conditions. Rating 25 watts. Individual bass and treble controls give ample "boost" and "cut". Two high impedance jack socket inputs are separately controlled. All controls are conveniently positioned in a recess on top of the cabinet. Cabinet is of substantial construction and attractively finished in two contrasting tones of Rexine and Vynair. Size approx. 24 × 21 × 13in. Operation from 200-250 v. 50 c.p.s. A.C. mains.

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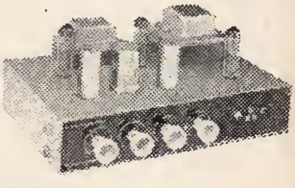
29½ Gns. Or Deposit £3.2.0 and 12 monthly payments of 51/8. Carr. 17/6.

HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE A.11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES



Two input sockets with associated controls allow mixing of "mike" and gram., as in A10. High sensitivity. Includes 5 valves, ECC83, ECC83, EL84, EL84, EZ81. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut". Frequency response—3 dB 30-30,000 c/s. Six negative feedback loops. Hum level 60 dB down. ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs for **STANDARD or LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, LEAD OR RHYTHM GUITARS,** etc. **OUTPUT SOCKET** with plug provides 300 v. 30 mA, and 6.3 v. 1.5 a. for supply of a **RADIO FEEDER UNIT.** Size approx. 12 × 9 × 7in. For A.C. mains 200-250 v. 50 c.p.s. Output for 3 and 15 ohms speaker. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. Only **8 Gns.** Carr. 10/-. (Or factory built 51/- extra.)

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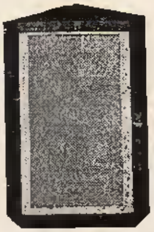
R.S.C. CORNER CONSOLE CABINETS



Polished walnut veneer finish. Pleasing design.

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STANDARD MODEL. Size 27 × 18 × 12in. for 8 or 10in. speakers, **£4.11.9.**

SENIOR MODEL. Size 30 × 20 × 15in. for 12in. Speaker. Suitable Speaker systems below. Only 7 gns.

R.S.C. BASS REFLEX CABINETS, JUNIOR MODEL. Specially designed for W.B. HF1012 Speaker, but suitable for any good quality 10in. speaker. Acoustically lined and ported. Polished walnut veneer finish. Size 18 × 12 × 10in. Handsome appearance. Ensures superb reproduction for only **£3.19.6.**

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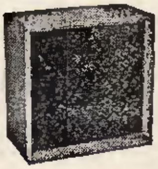
12in. 10-WATT HIGH QUALITY LOUDSPEAKER. In walnut veneered cabinet. Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only **£4.19.6.** Carr. 5/-. Terms: Deposit **11/3** and 9 monthly payments of **11/3. 12in. 20 WATT HI-FI LOUDSPEAKERS IN CABINETS.** Size 18 × 13 × 10in. Finish as above. Terms: Deposit **17/9** and 9 monthly payments of **17/9.** Only **£7.19.6.** Carr. 8/6.



AUDIOTRINE HI-FI SPEAKER SYSTEMS. Consisting of matched 12in. 12,000 line, 15 ohm high quality speaker, crossover unit (consisting of choke, condenser, etc.) and Tweeter. The smooth response and extended frequency range ensure surprisingly realistic reproduction. Standard 10 watt rating **£4.19.9.** Carr. 5/-. Or Senior 15 watt, **£6.19.9.** Carr. 7/6.

HEAVY DUTY LOUDSPEAKERS IN SUBSTANTIAL REXINE COVERED CABINETS. Type BG1. Suitable for Bass Guitar. Speaker Unit 15in., High Flux, 15 ohms, 30 watts. Cabinet size approx. 24 × 21 × 13in. Only **19½ gns.** Or Deposit **43/-** and 12 monthly payments of **34/-.**

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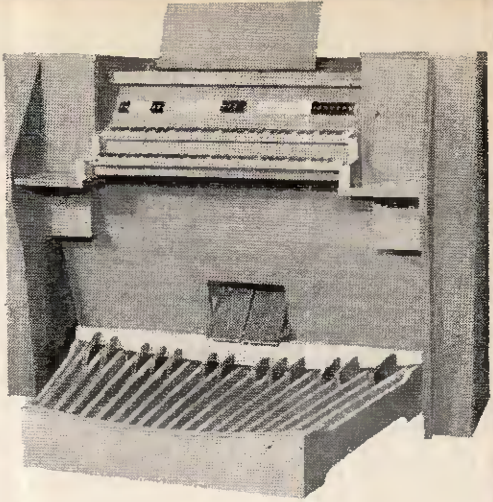

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VOL. 1 No. 2
DECEMBER 1964

Practical Electronics

Opportunities Abound

We are all, nowadays, electronics conscious. Yes, even the layman, while not conversant with the technicalities involved, has a general appreciation of the vital part played by this young but exuberant branch of electrical engineering in the complex world of today . . . and this is but the beginning.

★ ★ ★

As we step over the threshold into a new exciting technological age, our dependence upon electronics is all too apparent: terrestrial developments centre around automation, with electronics providing the brain and guiding hand for power-operated machinery; extraterrestrial exploration relies utterly upon electronics for remote control, communications and telemetering services.

These grand scale developments have an impact on the entire field of electronics, for in their wake come new components, new circuits, new methods and, of course, new applications.

★ ★ ★

Without a doubt the amateur enthusiast will be eager to reap his share of these benefits of technological progress, as he has been indeed in the past. For it is true that amateurs have been conducting experiments and building electronic equipment since the earliest days of radio communication; even before the thermionic valve drove the crystal diode into (temporary) oblivion, and long before the very term "electronics" entered into general use.

But, in more recent times, the technical revolution triggered off by the invention of the crystal triode or transistor some 16 years ago has quite dramatically transformed the situation to the advantage of the home constructor.

★ ★ ★

Thanks to the transistor, gone largely is the need for a metal chassis and the tedious metal work this often entailed. Much transistorised equipment can be assembled satisfactorily on a piece of plastics board or even on an offcut of hardboard. A small battery replaces a bulky and heavy power pack and so demolishes what was undoubtedly a psychological barrier for some would-be constructors and experimenters—apprehension of high voltage supplies. With miniature components and simplified assembly methods, construction can indeed be a kitchen table operation nowadays.

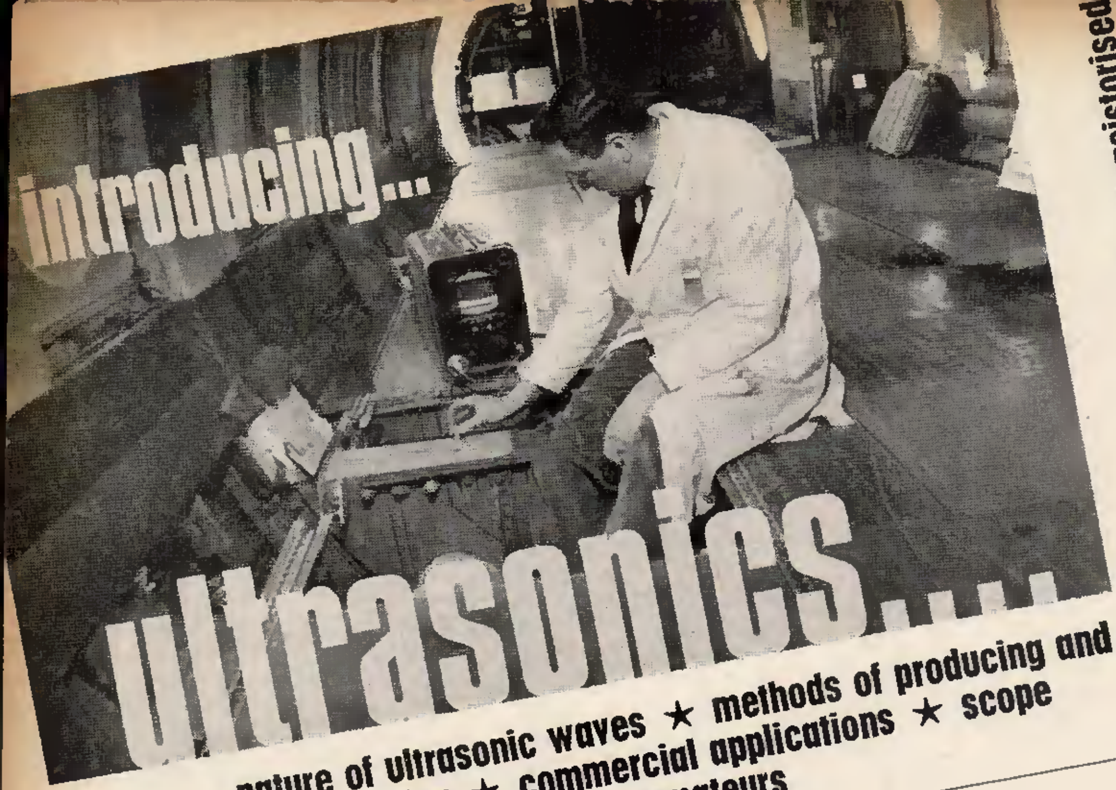
Yes, truly can we say that in the realm of electronics a new emphasis has been given to the word *practical*.

THIS MONTH

Our January issue will be published on Thursday, December 17

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2 Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 35s.

introducing... ultrasonics....



The Ultrasonoscope transistorised flaw detector being used for checking structural parts of an aircraft

nature of ultrasonic waves ★ methods of producing and detecting ★ commercial applications ★ scope for amateurs

ULTRASONICS IN NATURE

In the year 1793 Lazzaro Spallanzani established after a long series of experiments that the common bat could navigate and detect its prey without being able to see. After establishing that any loss of acuteness in the bat's hearing resulted in a loss of ability to navigate, he put forward the hypothesis that they were able to navigate and detect their prey by emitting and receiving a vibration of the same nature as that of sound but with such high frequency that it was inaudible to the human ear.

The scientific minds of the day rejected this suggestion, and Spallanzani joined the ranks of those scientists whose reward for systematic investigation and logical thought was ridiculed.

It is now quite firmly established that these ideas were correct and that other creatures, including the porpoise are able to use ultrasonic emission and reception for various means.

The definition of an ultrasonic wave is very simple, being a pressure wave whose frequency is higher than that to which the human ear will respond. It is generally accepted that 20kc/s is the lowest usable ultrasonic frequency, although in fact human audibility does not reach this high level.

The properties of an ultrasonic vibration are, since they are fundamentally the same as sound vibrations, identical with the properties of sound. They may be propagated in gas, fluid or solid, may be absorbed by soft surfaces, reflected by hard surfaces and refracted by changes in temperature and pressure of the medium in which they are propagated.

PRODUCTION AND DETECTION OF ULTRASONIC VIBRATIONS

There are three main techniques by which ultrasonic vibrations may be produced.

1. Magnetostrictive methods.
2. Piezo-electric methods.
3. Oscillation of air or fluid jets.

The first of these methods uses the fact that certain materials when subjected to a varying magnetic field undergo very slight changes in dimensions. A nickel rod is usually used as the core of a coil through which a high frequency current is flowing. The result of this is that the nickel rod is subject to a slight length change with the same frequency as the current through the coil.

The second method relies on the fact that certain naturally occuring materials such as Rochelle Salt or Quartz and certain man-made materials such as ceramics, including Barium Titanate and Lead Zirconate Titanate, are subject to a change in dimensions with a directly applied voltage.

If an oscillatory voltage is applied to the opposite faces of such a slab of material the material will execute vibrations at twice the frequency of the applied voltage.

The reason for the frequency doubling effect is that the domains, i.e. groups of molecules, which are normally random in their orientation change direction according to the polarity of the applied electric field. Hence both the positive and negative peaks of the applied voltage will cause the corresponding expansion or contraction which results in the frequency doubling effects.

If the material is originally polarised, i.e. all the domains are arranged to lie in approximately one direction by means of application of a large electric field in the early stages of manufacture, then the fact that these domains are not completely free results in the piezo-electric vibration being of the same frequency as the applied oscillatory voltage.

The third method of production is only of interest where very high power is required, usually for emulsification of suspensions, and relies on the principle of a high powered jet of gas or fluid impinging on a blade. Under these conditions the blade will execute ultrasonic vibrations, assuming due care has been given to the dimensions of the blade, which will be transmitted through the gas or fluid.

APPLICATIONS OF ULTRASONIC VIBRATIONS

Among the first fully developed applications of ultrasonics were the fields of cleaning, drilling, welding and soldering. In each of these cases the ultrasonic techniques have certain advantages over conventional techniques.

The advantage of cleaning, by immersing the object concerned into a tank of fluid in which ultrasonic vibrations are produced, is twofold: firstly, the tremendous reduction in time when compared with manual cleaning; secondly, the advantage that very delicate and complex assemblies, such as internal parts for valves or components, may be cleaned without the risk of physical damage which is present when using conventional cleaning methods.

By using an ultrasonic vibration in a solid rod one can drill through materials for which standard drilling methods are not very satisfactory, examples being crystals or glass, or other such brittle material. A second advantage when using this method for drilling is that one has dispensed with the necessity for a rotating bit, hence one can drill holes of any desired shape.

In the case of welding and soldering, the obvious advantage is that the tremendous production of heat which can destroy or impair the efficiency of delicate assemblies is avoided, and in the case of soldering the use of any form of flux becomes unnecessary. A further advantage to the soldering technique is that it can be used to solder materials not solderable by previous methods, for instance aluminium.

The third method of producing ultrasonic energy, the jet method, is used in the textile and food industries among others; a characteristic example of products which require a process of emulsification being peanut butter.

MEASUREMENT BY ULTRASONICS

Apart from applications involved in the field of production or manufacturing, such as those previously described, ultrasonic vibrations may be used for performing scientific measurements.

Examples of these are ultrasonic thickness gauges and flow meters.

If an ultrasonic vibration is propagated through a solid material, any change in the nature of the material will result in some reflection. By measuring the attenuation or the time taken for an ultrasonic wave to cover the total journey it is possible to estimate very accurately the thickness of the material. One example of the use of ultrasonics in this respect is the measurement of the thickness of fat on certain animals, such as pigs, and in this context has an obvious superiority over any other methods which might be devised.

By launching an ultrasonic vibration into a moving fluid and using the Doppler effect, i.e. apparent change in frequency with velocity, it is possible to measure the flow rate of the fluid concerned. Although there are simpler methods for flow rate measurement, this technique has the advantage that it may be used with either corrosive or very dangerous fluids. An example of the use of this technique lies in the measurement of the flow rate of molten sodium which is used for heat transfer in certain atomic reactors.

Although it is not a scientific measurement, the similar technique to that for thickness may be used to detect flaws in factory-made products without the necessity of destroying the product in the process of inspection. An ultrasonic vibration introduced at one face of perhaps a complicated plastics moulding will be reflected by any small voids or cracks in the material. These reflections may be compared with the pattern which is the result of a flawless product, hence inspection may be carried out very rapidly and without any destruction of the items concerned.

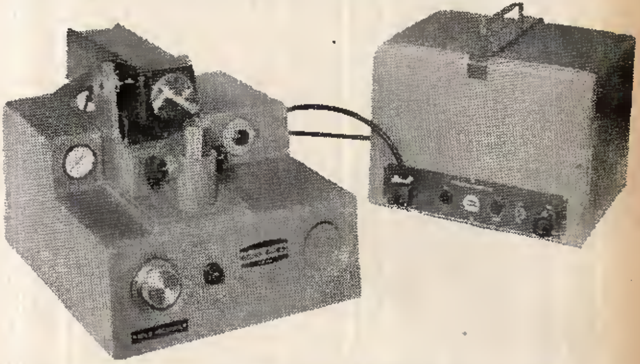
Probably the most dramatic use of ultrasonic energy is in the field of echo sounding. This is an extension of the thickness measurement technique by which a ship may launch an ultrasonic wave and establish the time taken for reflection from the ocean bed. This is a direct and continuous indication of depth.

Apart from indicating depth this technique may, of course, also be used to detect the presence and position of either ships or shoals of fish.

ULTRASONICS IN AIR

There are a number of ways in which the properties of an ultrasonic wave in air may be used to perform useful tasks. Probably the four main applications are in object detection, distance measurement, remote control and communications.

The property of reflection may be used in air, as it is in water, to measure the distance to a given object. This is exploited in devices which are available for the measurement of height of such things as hovercraft, helicopters and possibly light aircraft when flying at very low levels.



An ultrasonic spot welder for welding thin ductile materials such as aluminium and copper

When used for detecting objects the largest application is that of the burglar alarm. If a transmitter and receiver are set up some distance apart, and the incoming wave of ultrasonics to the receiver used via an amplifier to hold over a relay, anybody interrupting the beam will cut off the input to the amplifier, hence cause the relay to change position. This is used directly to indicate presence of intruders in factories, warehouses, etc.

This ultrasonic thickness meter incorporates a moving coil meter which indicates directly the thickness of metals being examined. It is fully transistorised and operates from dry cells

The Omega threadless stitcher. This uses a novel spot welding technique and is used in garment production with man-made fabrics

A similar system may be used for remote control or communication, but in this case the ultrasonic wave is directly controlled at the transmitter.

Since a pressure wave of this sort may be modulated in much the same way as a radio wave, with sufficiently sophisticated electronic equipment the transmitted ultrasonic wave may be either amplitude modulated, frequency modulated or pulse code modulated in order to transmit information or instructions over short distances.

Concerning the remote control of model boats, it must however be noted that control may be effected over much longer distances if the wave is transmitted through the water, since the attenuation of ultrasonic waves is considerably less in a liquid medium than in air.

The transmission of ultrasonic waves in air is a field which is very suitable for the experimenter as suitable transducers for transmitting and receiving are available commercially at comparatively low prices. Although the range of control is a little limited, something of the order of 100 to 300ft being the maximum practical at the moment, an ultrasonic system for remote control has certain advantages over radio control. The most obvious of these being the fact that the ancillary amplifiers are usually cheaper to make and considerably more simple. There is, of course, the added advantage that a transmitting licence is not required, as in the case of radio wave propagation.

ULTRASONIC TRANSDUCERS

When transmitting ultrasonic energy through air the direct use of a vibrating crystal is not the most satisfactory method since, although great power is available from such a crystal, the dimensions of the change in size are so small that the range would be very limited.

In order to improve this range a technique is used whereby the movement of the crystal is mechanically amplified to get a greater degree of movement from the transmitting element.

Fig. 1 shows the technique which is used to achieve this mechanical amplification. A thin crystal is cemented to a small thin round plate mounted on a central stem. As the crystal is energised it attempts to change its dimensions in the plane of its two parallel faces. Since it is securely cemented to the metal plate the latter is forced to bend with the movement of the crystal, and this results in an oscillatory bending movement of the metal plate at the frequency of the applied voltage—hence the transmission of a pressure wave into the air.

Correspondingly, a pressure wave impinging on the plate will cause very small movement of the plate which is sufficient to generate across the crystal a signal corresponding to the frequency of the incoming pressure wave.

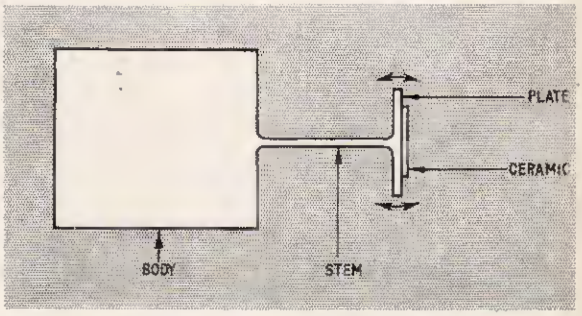


Fig. 1. Mechanical amplification of the transducer crystal is achieved by use of a small metal plate

THE EXPERIMENTAL APPLICATIONS OF ULTRASONIC ENERGY

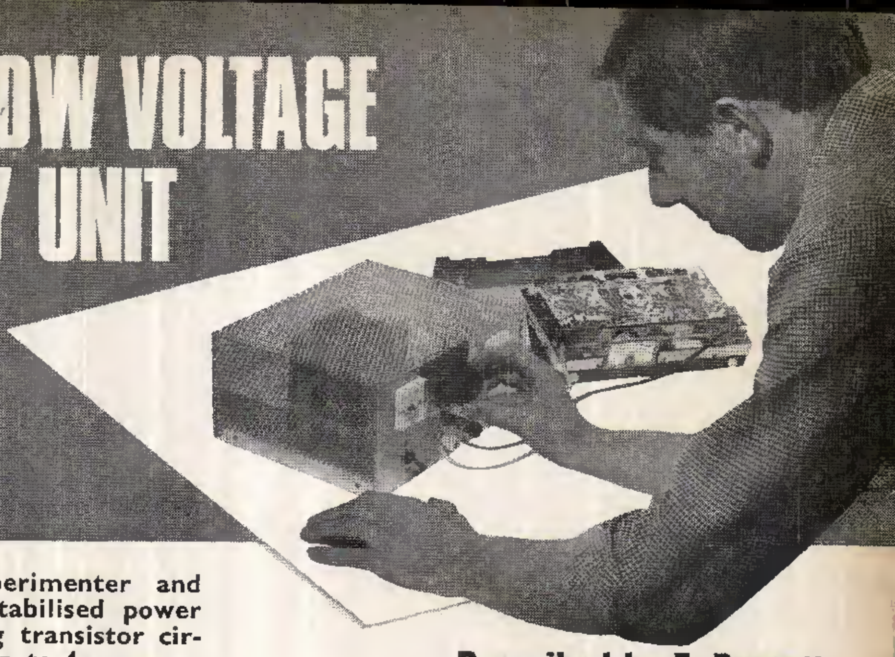
Most amateurs, or indeed small industrial users, are limited to the application of ultrasonics directly in air, as this is the only application for which the general purpose transducers are available on the market.

There are a number of aspects of ultrasonics which are certain to capture the imagination of the enthusiastic amateur, especially in the field of remote control and voice communication.

The fact that in this medium the experimenter is free from the necessity to acquire transmitting licences is a major attraction of these techniques.

In the case of amateurs or small industrial users who feel sufficiently confident to manufacture their own transducers from fundamental ceramic materials which are freely obtainable, the field of underwater transmission could be particularly exciting. This has the previously mentioned advantage of considerably greater range and would offer at least one immediate application, this being the facility of direct voice communication between aqualung divers.

VARIABLE LOW VOLTAGE D.C. SUPPLY UNIT



Designed to suit the experimenter and amateur constructor, this stabilised power supply is ideal for supplying transistor circuits with 0—14 volts d.c. at up to 4 amperes. It eliminates the need for expensive battery replacements when working on the test bench.

Described by E. Barnett

THE CIRCUIT (see Fig. 1 on blueprint) consists of a step down battery charger transformer T1 feeding into a bridge rectifier consisting of D1—D4, the output of which is smoothed by the 2,500μF capacitor C1 at about 22 volts off load.

The two Zener diodes D5 and D6 in series stabilise the base of TR1 to about 14 volts, thus maintaining the voltage at the top end of VR1 in the emitter circuit of TR1 at the same—since the gain of a grounded collector (or emitter follower) transistor is virtually unity.

Variation of the output voltage is carried out by "potting down" the variable resistance VR1, the slider of which feeds into the base of another grounded collector transistor TR2.

The output from across the TR2 emitter load is then fed into the bases of TR3 and TR4 connected in parallel, again in grounded collector configuration, the emitter load for these two transistors being the device to be supplied with power.

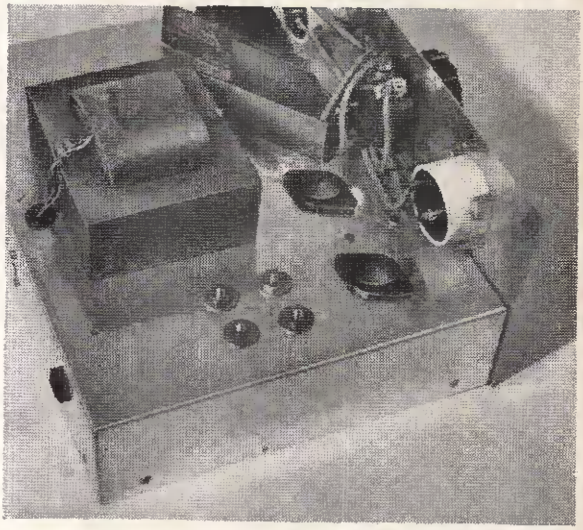
SEMICONDUCTOR DETAILS

When constructing the power supply, various precautions should be taken. Before mounting the transistors TR1–TR4 and bridge rectifier diodes D1–D4 ensure there are no burrs around the drilled holes in the chassis otherwise the insulating washers will be punctured and expensive smoke could be generated!

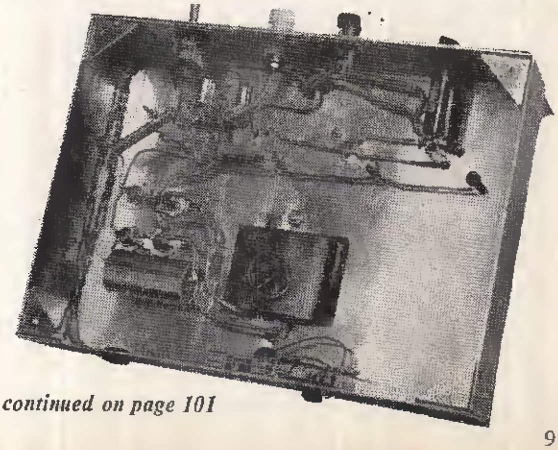
Also, prevent damage occurring to the face of the chassis where the transistors, diodes and heatsinks are to be mounted, since good thermal conductivity is essential for the long life of the semiconductors.

A smear of silicon grease on the chassis and semiconductor mating faces will assist heat conduction and maintain the insulation.

The insulating sleeves for diodes D1–D4 inclusive were cut from the outer casing of some old television coaxial cable; however, any form of insulating sleeving will do provided it functions properly.



Above is a top view showing heat sinks and transistors painted matt black for heat dissipation. An under chassis view is shown below

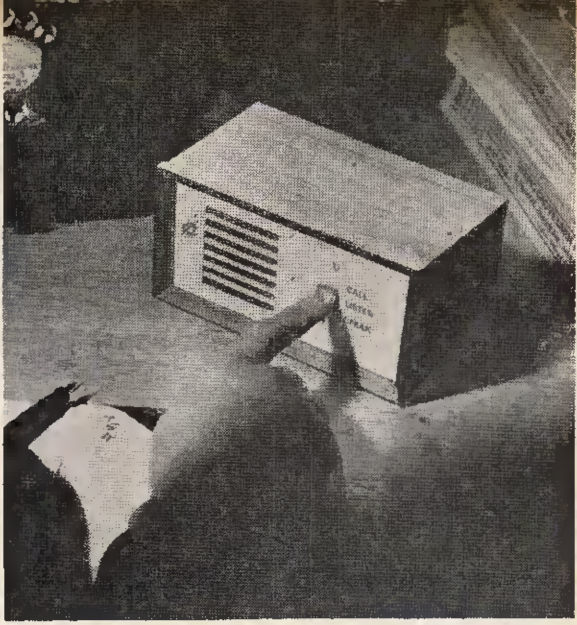


continued on page 101

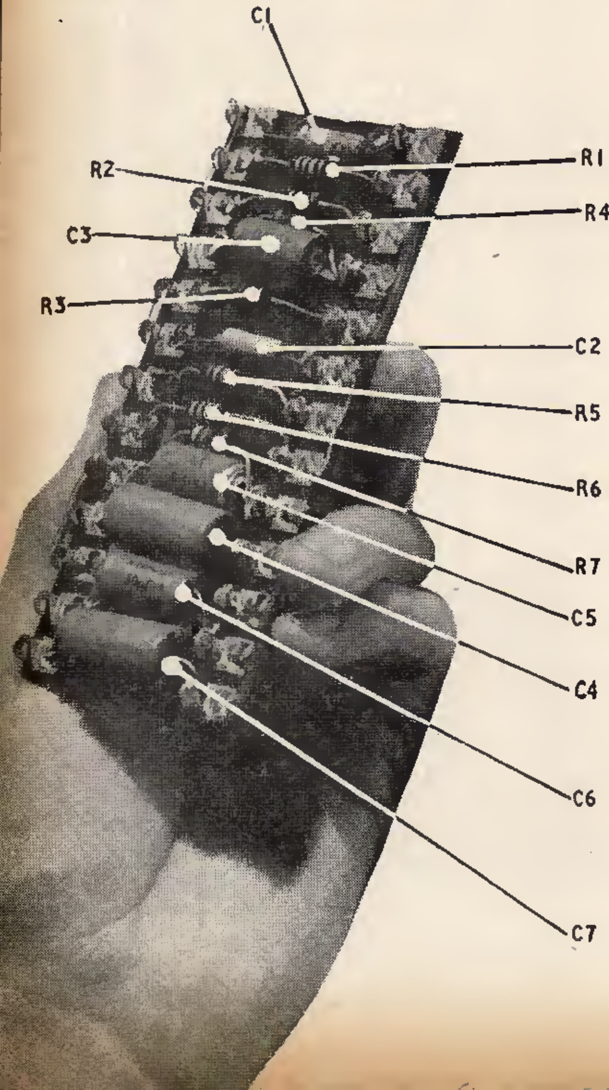
TWO WAY intercom UNIT

PE BLUEPRINT

By K. Berry



Construction of the intercom unit is simple • its finished appearance will enhance any desk or table in home and office • installation is easy, requiring only a two-cored cable between a pair of units

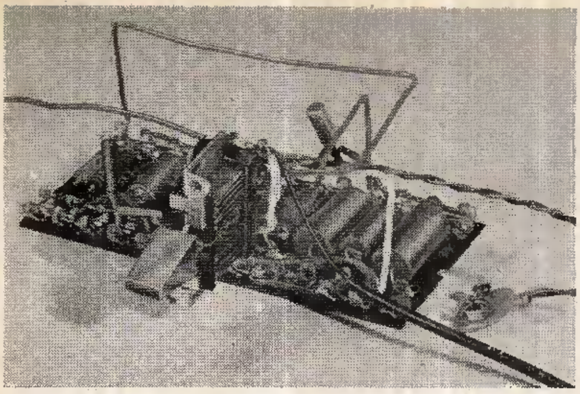


THE CIRCUIT of the amplifier which is the heart of the equipment is shown in Fig. 1 of the blueprint. It is a simple two-stage common-emitter transistor amplifier using germanium alloy junction transistors. It will be seen that there is no d.c. path shown for the collector current of the output transistor. This is because the collector current of this transistor goes down one of the line conductors to the loudspeaker in the other unit returning via the other conductor. The 0·1μF capacitor C4 which is connected from the collector to the negative supply reduces the impedance of the collector load at the higher audio frequencies thus lowering the effective gain of this stage at these frequencies. This overcomes a tendency to high frequency oscillation. The 32μF capacitor C6 connected across the supply lines was found to be necessary to prevent low frequency oscillation ("motor-boating") occurring when the battery runs down.

In Fig. 2 is shown the circuit of the rest of the unit. A four-pole three-position switch S1 selects the various functions. This switch is biased to its centre position ("LISTEN") and in this position only the loudspeaker/microphone is connected to line. When the switch is thrown to the "SPEAK" position, the loudspeaker/microphone is connected to the input of the amplifier and the line to the output (as described above). The other switch position is "CALL", and when the switch is held in this position the line is connected to the output of the amplifier and a 0·1μF capacitor C7 is connected from the output of the amplifier to its input terminal. This causes the amplifier to oscillate violently at about 500c/s and results in a loud tone being emitted by the loudspeaker in the other unit.

CONSTRUCTION AND COMPONENTS

An attractive cabinet constructed of wood with an aluminium facia panel is shown in detail in Fig. 4.



The photograph above shows the electronic assembly ready for inserting into the cabinet prior to connecting to the microphone/loudspeaker and battery

The transducer used as the loudspeaker/microphone is a Government surplus balanced-armature earpiece marked "I.T.B.A. No. 5", obtained from a pair of headphones. It might be possible to use a small high impedance moving coil loudspeaker (say 35 ohms) instead, *but this has not been verified.* In any case, the surplus headphones should be cheaper. *Note:* A suitable pair of headphones (type DLR5) from which two balanced-armature inserts may be removed is available from Z & I Aero Services, 44A Westbourne Grove, London, W.2.

The exact type of switch to be used will depend on what is available. Those used by the author were miniature key switches. The old Post Office key switch would serve the purpose well, but is rather large. Note that the switches used must be of the "break-before-make" variety.

TRANSISTOR VOLTAGES

Transistor	Collector	Base	Emitter
TR1	5·1	1·8	1·7
TR2	8·2	1·0	0·85

Total current consumption: 21mA "CALL"
16·5mA "SPEAK"
Above measurements made with AVO Model 8
Battery voltage 9V. Switch set to "SPEAK"

INSTALLATION AND OPERATION

Having made and tested the units on the bench, it only remains to install them. They should be connected by a two-core cable of sufficiently low resistance. The author has about 30 yards of 14/·0076 flat twin wire connecting his intercom units. Tests made on this installation show that a line "loop resistance" in excess of 220 ohms is acceptable. Using 14/·0076 wire this means a separation of up to 3,000 yards is possible, which should be quite enough for most purposes.

When connecting up it is desirable to connect the units so that the negative poles of the batteries in each unit are both connected to the same line.

To call the remote station, set the switch to the "CALL" position for about two seconds then release the switch and wait for the remote station to answer. When the remote station has answered, set the switch to the "SPEAK" position and pass your message. As soon as you have finished speaking, release the key so that you can hear the remote station. ★

VARIABLE LOW VOLTAGE D.C. SUPPLY UNIT

continued from page 99

The faces of heatsinks for TR3 and TR4 can be painted with a black paint which has a matt finish and must be heat resistant capable of withstanding temperatures of at least 100°C. The heatsinks (and transistors) should be painted *after* assembly since the mating faces must be clear of paint for good heat conduction.

The usual precautions of using heat shunts such as pliers and not applying heat for longer than is necessary should be taken when soldering.

CHASSIS DETAILS

The blueprint shows the chassis construction full size and from these drawings any dimensions can be taken off.

The chassis itself is a proprietry item that can be purchased from any dealer, and the cover was made from expanded metal and is fixed to the main chassis with self-tapping screws and washers.

When fixing the fuse holder for FS1 an insulating sheet is required between the chassis and holder otherwise a short circuit will occur.

Before fixing transformer T1 the fixing brackets were removed to facilitate "drop through" mounting to the chassis.

TESTING

Check for continuity and correctness of wiring and ensure polarity of connection of C1 is correct.

Check insulation of diodes D1–D4 and transistors TR1–TR4 between cases and chassis. Don't use a high voltage megohmmeter, the ohms × 100 range is sufficient on an AVO model 8.

Once satisfied with the wiring, rotate potentiometer VR1 knob fully anticlockwise, connect the mains power to the unit and switch on.

When VR1 is rotated clockwise the indication on M1 should rise from zero to 14V d.c. in the fully clockwise position. Should the response be different to above switch off immediately and ascertain fault. Next connect a 4 to 5 ohm resistor of at least 20 watts rating to the output terminals and adjust VR1 until 14 volts is reached on M1.

The ammeter M2 reading should remain steady at about 3 to 4 amperes depending on the value of load.

Transistors TR3 and TR4 will get very hot and TR1 and TR2 quite warm. This is normal.

OPERATION

The fuse rating in FS2 position will depend upon the application. For example, an average transistor radio may take up to 100mA and a medium power inverter may take up to the maximum rating of 4A.

Currents of 5 amperes and more can be handled *intermittently* but for good transistor life 4 amperes should not be exceeded.

Ambient conditions are important, too. Allow plenty of air-space around the unit and avoid operating it in places or near to objects of relatively high temperatures.

Regulation is very good, the change in voltage from no load to 4 amperes at 6 volts is less than 0·25 volt and at 12 volts less than 0·5 volt. ★

SINCLAIR X-10 AMPLIFIER

With reference to our New Products feature last month, it has been brought to our notice that Technical Suppliers Ltd. are *wholesale* distributors only. All individual retail enquiries concerning this amplifier should be addressed to the manufacturers: Sinclair Radionics Ltd., Comberton, Cambridge.

the 73 page

by Jack Hum G5UM

Curtain Up

To half a million enthusiasts in 200 countries practical electronics means the art of radio communication—and half a million is the approximate number of actual or would be transmitting amateurs the world over. Collectively, licensed amateur stations far outnumber all the broadcast, point-to-point and other professional service stations put together—and note that word "service". The amateur movement is a "service" and is designated as such in the International Telecommunications Union regulations agreed at Geneva in 1959.

These half-million members of the Amateur Service are truly at the service of the communities in which they live. They contribute know-how in practical electronics—that all-pervasive phrase again! They contribute even their stations when emergency communications are needed. They intercommunicate in the universal language of "radio English" (more about this another month) on six world-spanning frequency bands and three more local v.h.f. ones, by morse, speech, teleprinter and video. They are at once diverse yet homogeneous.

* * *

It is about these people that the present feature will talk. The Editor's brief to the writer is that this feature should address itself primarily to readers who are at an early stage in amateur radio rather than those that have been in it for many years. This does not mean that we shall be writing "a beginner's guide" to the art of amateur radio: there are plenty of *those* to be had from various sources at various prices.

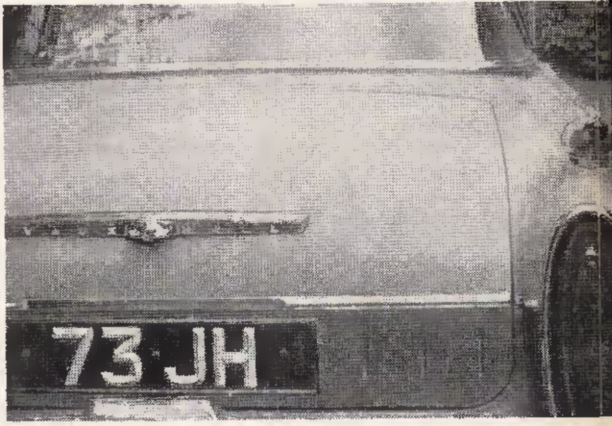
Rather, we shall aim to help as much as we can by discussing the type of questions that baffle enthusiasts with feet on a lowish rung of the amateur radio ladder hesitant to hoist them on to the next one up—questions such as "What type of receiver should I buy—or should I try to make one?"

Or again: "Which are the best bands to listen on and at what times—and what am I likely to hear on them?"

Recognising, too, that nearly every short wave listener aspires to acquire in time that coveted transmitting licence we will help as far as we can with advice on this most important point.

What of aerials? Or v.h.f.? Or "sideband"? Amateur radio's very diversity means that there is going to be much to discuss in *The 73 Page*, and we cannot promise to get round to covering all possible topics at short order. It will take time to deal with even a few of the subjects which currently occupy the attention of the amateur service.

However, we will try—and *your* comments will be welcome for discussion here should you feel inclined to write in on any aspect of this specialised part of practical electronics that interests you.



A friendly greeting to fellow (radio amateur) travellers is conveyed by this car registration number. It should not be necessary to tell you the owner's name!

Meaningful Number

Before one proceeds further a word or two about the running title to this feature may be to the point, for this title will headline it each time it appears (nice recognisability!).

Why *The 73 Page*? Because *73* is the most meaningful set of digits in amateur radio. It is the last thing a transmitting amateur says before he signs off a contact with a colleague.

It means *Best Wishes*. It is sought after as a motor car number, even as a house number. The Radio Society of Great Britain has it as its telephone number.

Its origin, lost in the mists of the electric telegraph, is believed to stem from abbreviations invented by the pioneers of the American railroad for quick communication between lonely signal cabins strung out across the prairies.

Today it is the most venerated phrase in amateur radio. We feel that none more appropriate could head this column.

Heart of "The Shack"—the Receiver

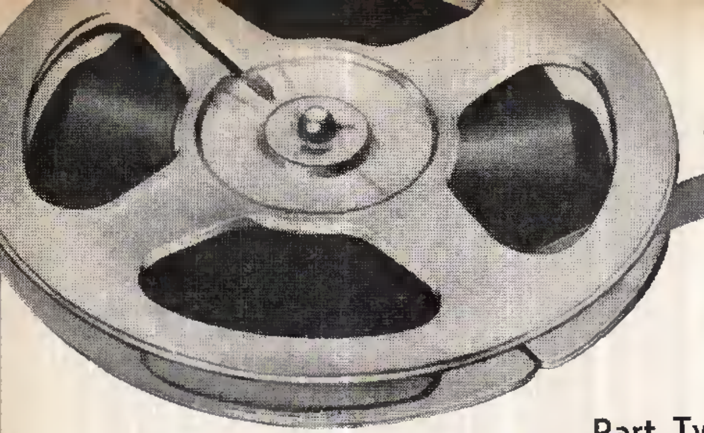
So much by way of introduction. Leaving generalities, now, and coming down to brass-tack practicalities, there is one question above all others that must be answered by every aspirant to amateur radio before he can ever begin to make a start. We have mentioned it already. It is: "What receiver?"

To find an answer to this question is not easy; it is a many-sided one. For the fully fledged communicator nothing will do but an advanced design of superhet receiver which has all the current refinements. But there are thousands upon thousands of enthusiasts who have not reached that stage—perhaps do not even want to!—yet are seized with a desire to make something of their own that will help them "to get their feet wet", something with which to paddle around in the every fascinating short wave spectrum.

To recommend suitable designs of receiving equipment (note the word "equipment": it embraces converters as well as receivers) would occupy the remainder of this number of PRACTICAL ELECTRONICS. To embark on constructional details about them would occupy several!

There are nevertheless certain signposts along the route to short wave listening which will be examined on *The 73 Page* later on, and the destinations to which they lead explored. A number of them suggest methods of approach that offer the delights of h.f. reception at remarkably little cost, coupled with the fulfilment that comes from building equipment yourself.

the
73
page by



Sound on Tape

A SHORT SERIES FOR THE HOME RECORDING ENTHUSIAST

By H. W. HELLYER

Part Two

Having chosen the machine that suits both pocket and purpose, it is necessary to make the best use of it; not merely to tape the budgie and baby's first words, then relegate the recorder to the niche beneath the stairs. Like the car fanatic or the photography fiend, the tape recording enthusiast will soon be casting around for ways to improve upon his investment, and to obtain the best possible use from his machine.

First let us consider the microphone. If a microphone is supplied with the machine, it may be assumed that this suitably matches the input circuit of the recorder. But it may be required for an additional microphone to be used; there may indeed be a requirement for several microphones, plus a gramophone or radio input, to record a "programme", such as the commentary to a ciné film. Some care is necessary in selecting both microphones and that vital piece of equipment which is used to combine their outputs, i.e. a mixer.

MIXERS

There are two types of mixer, the *passive* and the *active*. The former type consists simply of a selection of sockets, with matching resistors and perhaps variable attenuators acting as level controls for the various inputs. The output from this device is plugged into the tape recorder so that the combined signal modulates the tape in the same way that a single microphone would. But such a device has severe limitations; there is bound to be an insertion loss, and it may not be possible to adjust the level controls to give sufficient combined output to modulate the tape correctly.

The answer to this problem is to use an active mixer, or mixer/pre-amplifier. There are many different types on the market, the simplest being a transistorised, single-stage amplifier to boost the low level signals to an acceptable voltage for the "radio/pick-up" input of the tape recorder, while mixing the microphone signals as before, and providing attenuation of the latter to match the inputs.

More comprehensive models use several separate pre-amplifiers for the different inputs, with individual gain controls, and perhaps a magic eye type of modulation level indicator. This type of device is intended to apply a signal to the high level input of the tape recorder, and will give better quality recordings because of the better signal-to-noise ratio.

The electronic mixer will have inputs for different types of microphone and other sources and should, properly, have a cathode follower output so that it may be used at a distance from the main machine, the signal transfer then being at low impedance.

For serious recording, a good mixer unit is indispensable. Fortunately, this is not a difficult item to construct; and circuits for suitable types will no doubt appear in future issues of Practical Electronics.

MODULATION LEVEL

Mention has already been made of the need for applying a signal of adequate strength to modulate the tape. The correct modulation level makes all the difference between a recording that is acceptable, and one that is either weak and hissy or overloading into distortion on peaks of sound.

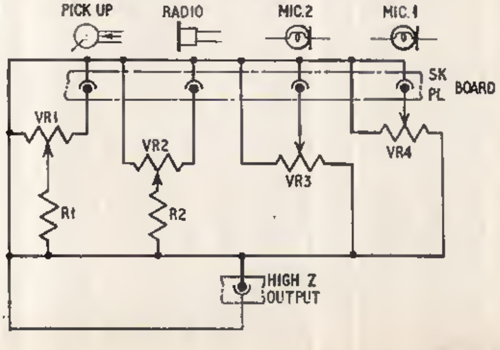
It is worth while spending some time experimenting with one's tape recorder to find the correct modulation level for a known input.

If a magic eye is fitted, the leaves or bar of the eye should nearly meet on peaks, but not overlap, and the input gain should be adjusted for this optimum. If a weak input is used, the replay will have to be turned up more to compensate for this and the upshot will be a higher level of amplifier noise as well as the required signal.

The dynamic range of the individual machine will have to be determined by trial and error. At the lower level the hiss of tape noise will outweigh the recorded signal when this is played back. At the upper level the amplified signal will overload the machine and cause distortion.

Where a meter is used for signal level indication, or modulation level readings, it is possible to assess the optimum recording level more accurately. But the type of meter, and the associated circuit, needs some

Fig. 2.1. A four-channel passive mixer. The values depend on matching and signal sources. If a low impedance microphone is used, a transformer is inserted with, as a refinement, a phase-reversal switch



consideration. Apart from the inherent sluggishness of a moving coil meter, compared with the quicker response of a magic eye to electrical changes, there are circuits deliberately designed to average out the sound changes and give a mean level indication. Some meters indicate volume units rather than peak readings. There are various methods of obtaining indications, and again, information concerning the conversion of a "domestic" tape recorder to more professional standards with meter indication in place of, or in addition to, the magic eye, will probably follow in due course. It is a subject worthy of some attention.

Whether a meter or magic eye is used, the aim is to record at a level which approaches the maximum modulation level. If the machine is correctly adjusted, this should give the best signal-to-noise ratio. But exceeding this value will bring about distortion, due to a clipping of peak voltages in the amplifier circuit. When using a meter, the correct level, if not indicated, must be assessed by trial and error. With a magic eye indicator, the illuminated "leaves" or "column" should approach one another, but not overlap.

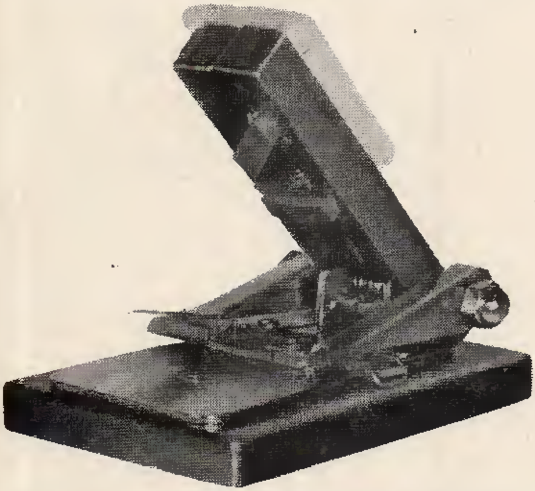


Fig. 2.2. A typical splicing block. Two cutters are incorporated; one makes a diagonal cut across the two ends of tape, the other is used to trim the edges of the jointing strip after this has been placed in position

The correctly modulated tape is then played back, and the controls adjusted for comfortable listening level. Control of tone is also carried out during playback. The circuits are intended to produce a "tailored response" during recording so that the replayed output follows the equalised response curve exactly. Tone modification can then be made to taste.

TEST SIGNAL

To test the correct setting of the modulation level indicator, a steady signal, as pure as possible, is required. We have a ready-made test source in the television test signal that precedes a programme and is also broadcast several times during the test card periods of the morning on both BBC and ITV. This is a steady tone, a sine wave, and, provided the television receiver is in good order, the output should be level and unvarying.

This signal is applied to the tape recorder—see later notes on this subject for the actual manner of connection—or alternatively the microphone can be used to pick up this sound, providing one is working in quiet surroundings.

Begin recording the tone on a clean tape, with the record gain control at its low level, and advance the control a regular amount every ten seconds. Note the position of the control and the closure of the magic eye. If a more accurate record of these steps is required, use a chinagraph pencil to mark the edge of the illumination on the glass envelope of this valve. These marks are easily rubbed off when the test is complete; the chinagraph pencil is a useful aid for editing purposes, enabling one to mark the outer surface of the tape, also, without damage.

Take a note of each step in this test, advancing the control until the illuminated portions overlap, and then a step beyond. Play back this recording, noting the steady increase in sound with each step, until an *edginess*, or harshness, is noted, with the sound at its loud level. Make a note of this portion of the tape, check against your listed magic eye indications and it should be found that the distortion has crept in at the stage when the illuminated portions just overlap. One has then a standard to which future recordings can be made.

A few tests like this will show why it is necessary to mix inputs correctly. There is an optimum level of input, at which the machine will give of its best. While a modern crystal microphone may give between 1 and 2 millivolts of signal, the output from a radio diode circuit may be 10 times as strong for adequate signal-to-noise ratio, and the output from a gramophone pick-up 10 times as strong again.

EDITING

Far too many tape recorders are purchased and then wasted. The tape that was supplied with the machine is used over and over again and there is an almost psychopathic abhorrence of editing.

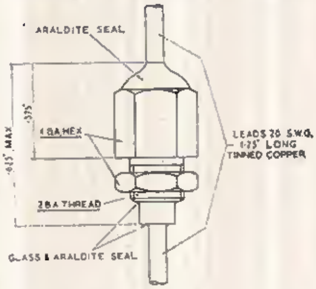
Considering that the average tape of a radio programme has at least five cuts, and a playlet, for example, may require fifty splices of tape, there is certainly nothing to be lost be editing. Indeed, the experienced tape user will realise how much is gained by the excision of those agonising "ums and aahs" and the general tightening up of a script or programme.

TAPE SPLICING

There are many tape splicers on the market, varying from the simple slot in a block to the elaborate devices with clamps and clips and measuring scales. Whatever method is used, the technique is to make a cut which matches the angle of the joining piece of tape (which is why a splicer is a better idea than a kitchen knife on the corner of the table). The ends are laid together and a piece of jointing adhesive fixed across the back of the joint; that is, on the shiny side, not the duller, oxidised side, of the tape.

Ordinary adhesive tape must never be used for joining tape, however good its quality. When the tape is spooled and stored, the adhesive of "parcelling tape" tends to creep, causing the adjacent turns to stick and then jerk from the spool as the tape unwinds when next used.

The reason for the angled cut is to avoid a click as the splice passes the head on replay. For the same reason, a clean splice is required, with no gap between the ends. The duration of a splice passing the head gap is quite insignificant for ordinary work and, if properly done, should be unnoticeable.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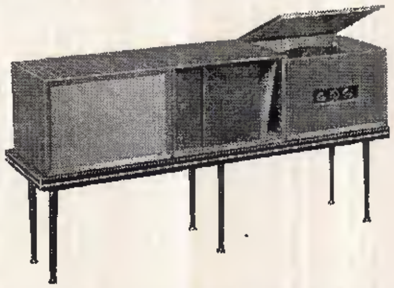


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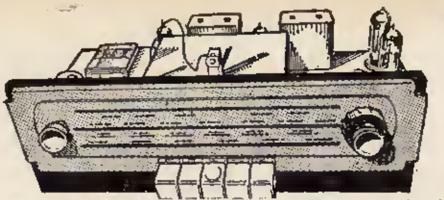

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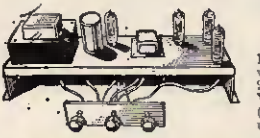
10 × 6in. ELLIPTICAL SPEAKER 25/- to purchaser of this chassis. **TERMS:** (Chassis) **£3.10.0** down and 5 monthly payments of £2.4.0. Cheap Room Dipole for V.H.F., 12/6. Feeder **6d.** per yard. **ALTERNATIVE DESIGN.** L.W. 1000-1900 M.; S.W. (9-15 Mc/s); M.W. 190-475 M.; V.H.F. 87-100 Mc/s: Gram position. Otherwise similar to above chassis. Price **£15.15.0** (carr. paid). **TERMS: £3.10.0** down and 6 monthly payments of £2.4.0. Circuit diagram **2/6.**



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5¾in. Double play, 1,800ft.	22/6
7in. Stand. play, 1,200ft.	12/6
7in. Long play, 1,800ft.	19/6
7in. Double play, 2,400ft.	25/–
TRIPLE PLAY	
3in. 450ft.	12/6
4in. 900ft.	22/6
5in. 1,800ft.	42/6
5¾in. 2,400ft.	55/–
7in. 3,600ft. (unboxed)	75/–

P.V.C. BASE	
5in. Standard play 600ft.	8/6
5¾in. Standard play, 850ft.	11/6
ACETATE BASE	
5in. Stand. play, 600ft.	8/–
5in. Long play, 900ft.	10/–
5¾in. Long play, 1,200ft.	12/6
7in. Long play, 1,800ft.	15/–
MESSAGE TAPES	
3in. Stand. play, 150ft.	3/6
3in. Long play, 225ft.	4/11
3in. Double play, 300ft.	7/6
3in. Triple play, 600ft.	14/–

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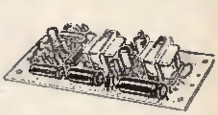

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PRECISION DECIMAL STEP PRE-AMPLIFIER

by M.L.Michaelis M.A

THIS article sets out to discuss some of the important practical questions involved in the design of a universal pre-amplifier with transistors, capable of both audio and metric applications. A complete design is given as well, detailed drawings appearing on the blueprint included in this issue of PRACTICAL ELECTRONICS. This pre-amplifier was developed and built by the author primarily for use between the probe and Y-amplifier input of an oscilloscope and for use with a transistorised tape recorder for various laboratory experimental purposes. Obviously many further applications exist.

GENERAL CIRCUIT DETAILS

Fig. 1 on the blueprint shows the complete circuit diagram of the prototype. This comprises two separate circuit cards, each having a gain of exactly 10. A central switch S1 connects either one or both of these cards between the input and output terminals, giving gains of exactly 10 or 100 respectively, or, in its third position, it switches the unit off.

The left hand card VB1 contains three cascade transistors TR1–TR3 and a d.c. peak bypass input circuit to the base of TR1. The latter is an essential feature in a universal unit of this nature, to prevent destruction of the transistors due to d.c. charging surges of anything up to several hundred volts when connecting the input to the anode circuits of valve equipment.

It may seem strange to use three transistors for a gain of only 10, but this is necessary to achieve the required high constancy. When properly built and adjusted, this circuit shows no perceptible change of gain (as displayed on an oscilloscope or meter) over temperatures from the freezing point up to over 50°C (over 122°F), or for battery voltage variations between 6V and 11V.

The pre-amplifier design here described should be suitable for tropical temperatures when shielded from the direct rays of the sun, or for European summers, outdoors in full sunshine. Even considerable heating indoors, due to standing the unit on top of valve operated items of equipment of high power dissipation, should give no gain fluctuations or other troubles.

With the assurance that the gain really is rock steady throughout all working conditions likely to be met, it was convenient to make it exactly 10 per circuit card, wherewith the complete unit is a decimal-step pre-amplifier. The great advantage thereof is that, when used in conjunction with calibrated oscilloscopes, or with a.c. voltmeters, the existing scales can still be read-off and mentally multiplied or divided by powers of 10, i.e. a mere shift of the decimal point is required.

The right hand circuit card VB2 contains another identical cascade of three transistors TR4–TR6, giving a gain of 10 once again. The only difference compared to the first card is that the d.c. peak bypass circuit is here omitted, because the input signal is always applied to VB1. The right hand circuit card VB2 also contains the emitter follower output stage TR7.

The circuit of VB1 is always operative, in both the gain 10 and gain 100 settings of the complete pre-amplifier. In the gain 10 setting, TR7 is switched directly onto the output of TR3 in VB1 and TR4–TR6 idle with C4 shorting the base of TR4 for a.c. to prevent parasitic instability. C4 is connected up to the negative supply line (and not to chassis) for this purpose, to prevent application of d.c. voltages of incorrect polarity; either connection would be just as good for pure a.c. signal considerations.

In the gain 100 setting, the output of VB1 is connected through to the input of VB2, via C4, and the output at TR6 is connected through to TR7.

IMPEDANCE

If the pre-amplifier is to be used for metric purposes between the probe and the input socket of an oscilloscope or valve voltmeter, the input impedance must be equal to that of the instrument in question.

In the published design the input impedance at PL1 has been adjusted to exactly 135 kilohms to match the Y-amplifier input impedance of the author's oscilloscope. *Adjustment of the input impedance to other values will be fully discussed later. But, in brief, it should be explained that this will involve a change of values for R3, R4, R6, R8, R9, VR1, and VR2, also possibly the replacement of TR3 by an OC304.*

The output impedance at PL2 is very low, as given by the setting of VR2 or VR4 (the respective base feeds for TR7 in the gain 10 and gain 100 settings) divided by the current gain of TR7 (about 20); it is, in fact, about 500 ohms. The purpose of this low output impedance is to permit arbitrary lengths of uncompensated coaxial cable between the output and the oscilloscope Y-amplifier input without loss of bandwidth due to cable stray capacity.

TABLE 1: GENERAL & EXPERIMENTAL USES OF THE DECIMAL STEP PRE-AMPLIFIER

AUDIO INPUT FROM	SET S1 FOR GAIN OF	AMPLIFIED OUTPUT TO
crystal microphone or moving coil microphone with transformer	100	gramophone socket (pick-up) of domestic radio or simple amplifier
moving coil loudspeaker as microphone, without transformer	100	ditto
moving coil loudspeaker as microphone, with reversed output transformer (step-up) as matching	10	ditto
magnetic pick-ups	10 or 100, according to type	ditto
any microphone, close to decimal step pre-amplifier	10 or 100, according to length of cable to main amplifier	microphone input of *distant* public address amplifier (field-work over large areas)
crystal set or simple diode receiver .	100	4,000 ohm headphones
any audio signal arising during experiments (many pulsed signals can also be handled—e.g. from photocells, Geiger counters, etc.)	10 or 100, as required	wherever required, unamplified signal having been insufficient

As far as audio uses are concerned, the low output impedance gives satisfactory performance on 4,000 ohm headphones, or even on ones of somewhat lower impedance, and long runs of screened cable are permissible from the output to a remote main amplifier without loss of treble when using the unit as a microphone head pre-amplifier.

PERFORMANCE

The bandwidth of the pre-amplifier as described in this article extends from 2c/s at the low frequency end on either gain setting to about 100kc/s at gain 100 or about 150kc/s at gain 10 at the high frequency end. These figures refer to the so-called 3dB-down points, i.e. the gain has dropped to one-half of that at mid-band frequencies at these limits. The response is substantially flat over the entire "hi fi" audio frequency range from 20c/s to 20kc/s and some way beyond either end.

Harmonic distortion is extremely low up to drives giving an output of 1 volt r.m.s.; it is not visible as deformation of a sinewave on an oscilloscope up to this signal level, a fairly sensitive visual test. Phase-shift is negligible, so that pulse and transient responses are excellent.

The unit is thus equally satisfactory for both high fidelity audio work and for waveform display on an oscilloscope.

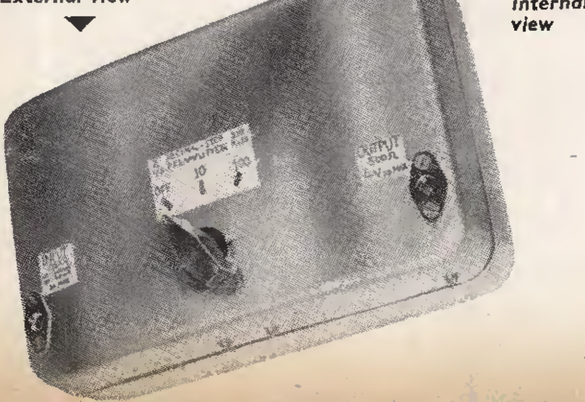
APPLICATIONS

Fig. 8 shows the manner in which the pre-amplifier may be connected to increase the Y-deflection sensitivity of an oscilloscope. The input impedance of the pre-amplifier must of course be adjusted to match the oscilloscope.

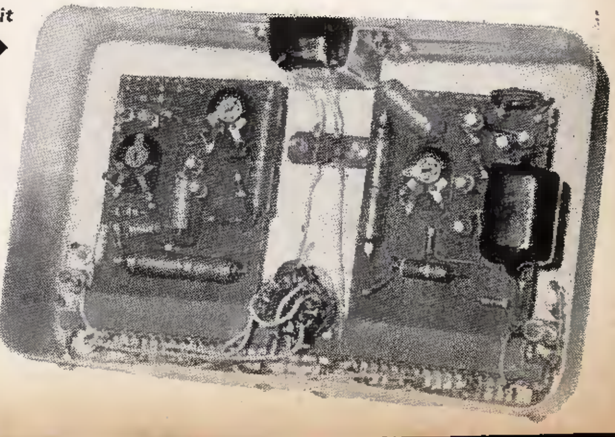
Fig. 9 sketches the arrangement to be adopted when using the pre-amplifier to increase the sensitivity of any a.c. valve voltmeter. The impedance matching requirements are here the same as for oscilloscopes if one desires to use the existing probe of the valve voltmeter at the input of the pre-amplifier while maintaining exact decimal step sensitivity increases.

If a simple diode peak rectifier circuit is interposed between the pre-amplifier output and the meter input, d.c. valve voltmeters or high resistance multimeters

Complete unit External view ▼



Complete unit Internal view ▶



PRECISION DECIMAL STEP PRE-AMPLIFIER

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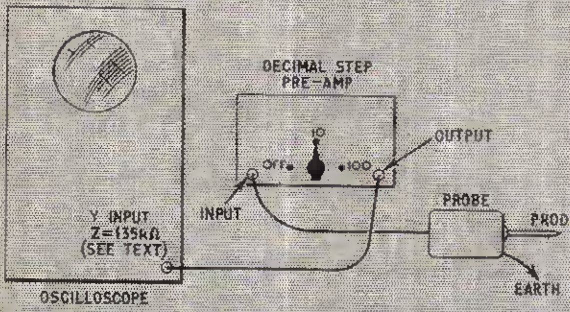

FIGURE 8

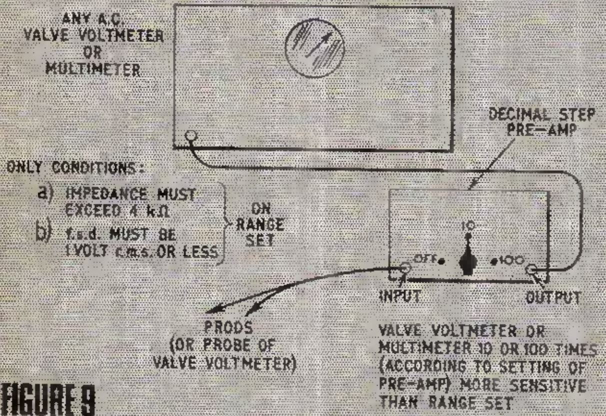

FIGURE 9

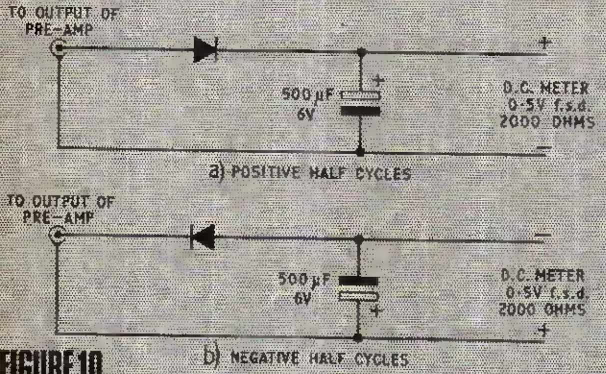

FIGURE 10

Fig. 8. Decimal step pre-amplifier used to increase Y-deflection sensitivity of an oscilloscope

Fig. 9. Method of increasing the sensitivity of an a.c. voltmeter

Fig. 10. Use of decimal step pre-amplifier to convert 0·5V f.s.d. meter to 5mV/50mV f.s.d. a.c. voltmeter

on low d.c. ranges may therewith be converted to sensitive a.c. "valve" (transistor) voltmeters. There are no impedance matching conditions to be observed in this case, provided that the meter and rectifier circuit impedance is much greater than the output impedance (500 ohms) of the pre-amplifier. Multimeters having a resistance of 4,000 ohms per volt and upwards on the d.c. ranges can thus be operated from the pre-amplifier output.

Fig. 10 shows a suitable rectifier circuit to make the meter indicate peak volts of one polarity. Reversing the diode and the connections to the meter makes it indicate peak volts of the other polarity. In the case of arbitrary non-sinewave signals applied to the input of the pre-amplifier, where the peak voltages on negative and positive half cycles may differ, corresponding different readings will be obtained.

Taking the Caby Model B20 multimeter as a typical example, we have a lowest d.c. voltage range of 0·5V f.s.d., 2,000 ohms impedance, available on the meter. This is satisfactory in every way for connecting to the output of the pre-amplifier via the rectifier circuit of Fig. 10 which may be built into the coaxial connecting cable fitting PL2 on the pre-amplifier at one end and the multimeter terminals at the other end. The multimeter is therewith an a.c. voltmeter giving full scale deflection for 50mV peak or 5mV peak (gain 10 or gain 100 settings respectively) applied to the pre-amplifier input, an excellent sensitivity. Moreover, the arrangement is usable not only at power mains frequency, but at any frequency over the entire hi fi audio range. If measuring positive and negative half cycles separately where these differ, it is important to remember that the pre-amplifier inverts the signal in the gain 10 setting, but not in the gain 100 setting.

Table 1 lists some typical audio applications of the pre-amplifier. These certainly do not require the accurate decimal step and stabilised gain, but it is, in the interests of universality, necessary to point out that the pre-amplifier is in every way suitable for such applications as well.

THE VEROBOARD SYSTEM

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The VB2503 panel is made of plastics card drilled over its entire surface with a square grid of holes having 0·15in spacing, 16 holes across the width and 21 holes along the length. The rear side only is fitted with 16 parallel strips of copper, each respectively running along one row of 21 holes along the length of the panel. These strips are thickened and gold-plated at one end, where the whole card plugs into a linear 16-contact socket.

Components are arranged on the front side (Fig. 2 and Fig. 4), where there are no copper strips; the wire ends are pushed through holes at respectively convenient positions, soldered with a spot of solder at the rear where they pass through the copper strip, and then cut off close.

If alterations are subsequently required, melt the solder by applying an iron at the rear while pulling the component wire with pliers from the front. Then jab a piece of bare tinned copper wire through the hole

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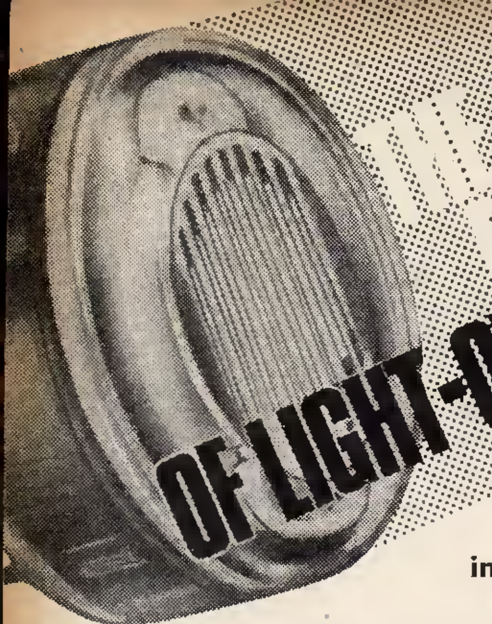

THE ELECTRONICS OF LIGHT-OPERATED SWITCHES

Described by G. J. KING

Our heading illustration shows the Mullard ORP cadmium sulphide photoconductive cell. The sensitive element is contained in a glass dish 14mm in diameter and 8mm deep

THERE are hosts of applications for a device capable of switching electrical contacts on or off automatically when its light-sensitive control element is subjected to changes in level of illumination. A typical application is for switching on a car parking light at dusk and switching it off again at dawn without human control.

A similar application is for switching on house, shop, office, factory or street lights when the ambient illumination drops below a predetermined level, and for switching them on again when it rises. This does away with the old-type time-switch. This application is also useful to discourage unwanted visitors when the house is left unoccupied for any lengthy period, such as during holidays and so forth.

Other applications include the automatic opening of the doors of a garage when the light-sensitive element picks up the rays of the headlights of the oncoming car, the counting of articles as they drop through and thus interrupt a ray of light which is directed onto the light-sensitive element, a smoke alarm, for use in smokeless zones, where a ray of light is interrupted by the presence of excess smoke in a chimney flue or stack, this reducing the intensity of light falling upon the light-sensitive element . . . and so on.

The basic functions of light-operated switches are the production of a potential, the change in a potential or the change in characteristics—such as resistance—of the light-sensitive control element. Such effects can be utilised to energise or de-energise a relay, thereby opening or closing a pair or more of electrical contacts, which in turn operate a light, bell or other alarm device, or an electric motor often in a form of servo arrangement.

BASIC CONTROL

In cases where the control current is very high, a secondary relay with a heavier set of contacts than those of the primary relay is controlled by the contacts of the primary relay. The basic controlling features are shown in Fig. 1.

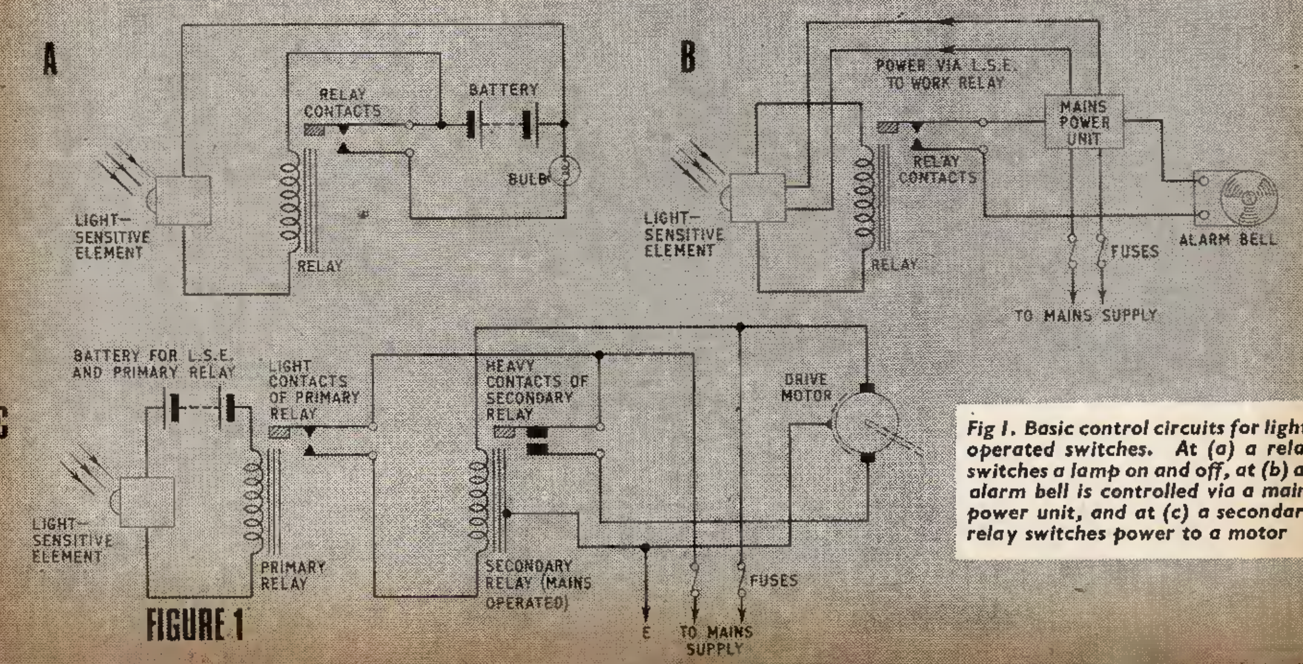

FIGURE 1

Fig 1. Basic control circuits for light-operated switches. At (a) a relay switches a lamp on and off, at (b) an alarm bell is controlled via a mains power unit, and at (c) a secondary relay switches power to a motor

At (a) we have the straightforward case, such as may be used to switch a parking light on and off. Here the battery could be the car accumulator (6 or 12V). This battery, being a d.c. supply, could both operate the relay by way of the light-sensitive element and work the bulb in the parking light.

The idea is that during the day the light-sensitive element in conjunction with its control circuit would pass insufficient current to energise the relay. The contacts thus remain open and the bulb extinguished. At lighting up time, however, the light-sensitive element and associated control produces an increase in current from the battery through the winding of the relay. This energises the relay, closes the relay contacts and thus passes battery current through the bulb which then lights.

At this juncture it should be noted that the arrangement could be reversed. That is, the relay could be energised during the daylight hours, under which condition the contacts would be *open*, and then de-energised during the night time, when the contacts would be closed to pass battery current through the bulb. It is just a matter of choosing the required light-sensitive element controlling circuit and relay.

At (b) we have a little more complicated arrangement, where a mains power unit is employed both to operate the alarm bell and the relay, the latter via the light-sensitive element and its associated circuit.

At (c) is shown an arrangement which features two relays. Here the primary relay is operated by a battery in the light-sensitive control circuit. When the contacts of this relay close, power from the mains supply is caused to pass through the winding of the secondary relay, which is a mains-operated type. The heavy contacts of this relay then close and pass mains power to the drive motor, which may work a garage door or some other mechanical device.

It is possible, of course, to make the whole control unit mains-operated to avoid the battery for the primary relay. This could be accomplished by an extension of (b), where a mains power unit supplies a d.c. voltage for the relay and light-sensitive control circuit, or by using a mains-operated primary relay.

So much, then, for the basic control and relay circuits, but what about the light sensitive element itself?

LIGHT-SENSITIVE DEVICES

An early light-sensitive element was the photo-electric cell. This was used extensively not only for controlling switching circuits by light but also for the replay of sound tracks on cine films. The photo-electric cell is, in fact, still used for the latter application, but other light-sensitive elements are better suited for control work. The photo-electric cell is a device which delivers a small amount of electricity (potential) when light is directed upon it. The greater the light intensity, the greater the potential, within limits, of course.

Recent innovations include the phototransistor and the photoconductive cell, the latter being illustrated in our heading, and it is mainly about these that this article will be concerned.

Let us first look at the phototransistor. This works in a similar way to a normal transistor into which light is allowed to enter. A transistor is, in fact, a light-sensitive device, but its usual opaque coating prevents it from responding to changes in level of illumination.

PHOTOTRANSISTOR

However, the phototransistor is a transistor designed to fully exploit the inherent photo-electric properties. It can be considered as a light-sensitive semiconductor junction diode (photodiode) in which the light current is amplified by the normal transistor action.

The forward current in any semiconductor diode is caused by a uniform interchange of current carriers across the junction. These can be electrons moving in one direction and positive holes moving in the opposite direction.

This unhindered flow across the junction, giving rise to the normal flow of electricity, results because the potential applied across the junction is in opposition to and outweighs the so-called "potential barrier" which is formed across the junction when it is manufactured, due to the initial diffusion of current carriers.

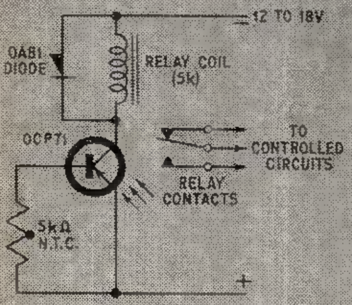

FIGURE 2

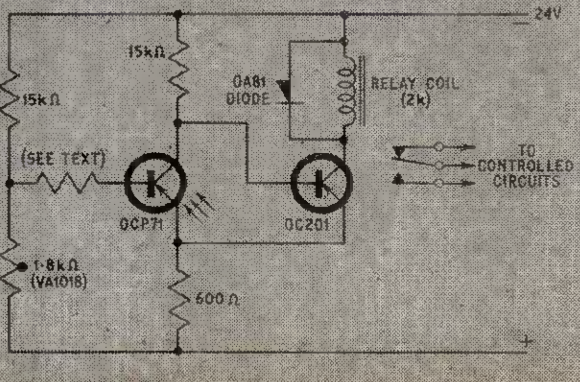

FIGURE 3

Fig 2. A basic switching circuit using the Mullard OCP71 photo-transistor
Fig 3. By the use of a transistor d.c. amplifier, the sensitivity and temperature stability are enhanced, as this circuit shows

The potential barrier is thus broken down by the applied forward potential.

Now, when the diode is biased in the reverse sense, the inherent potential barrier is effectively reinforced. This means that normal current flow is prevented because the barrier prevents the interchange of current carriers. Thus, we have the normal rectifier action where current can flow freely in one direction and is virtually prevented from flowing in the opposite direction. The same effect is exhibited by a diode valve, of course.

However, with a junction diode there is some difference. With a thermionic valve diode, if the anode is negative with respect to the cathode, no current whatsoever will be passed. But with a semiconductor diode, a "leakage current" results under this reverse-biased condition. This is because of a flow of "minority carriers" (these being positive holes in *n*-type material and electrons in *p*-type material).

In effect, the minority carriers tend to multiply when light is allowed to fall on the junction. The leakage current then rises, and as the light intensity increases, so does the leakage current increase. The normally low leakage current when no light is falling on the junction is called the "dark current", and the higher value of leakage current when the junction is illuminated is called the "light current".

The light-to-dark current ratio is enhanced considerably by amplification due to the normal transistor action of the device, and with a well designed circuit this ratio can be made as high as 480 at a temperature of 25 °C. Temperature comes into it because the minority carriers also tend to multiply as the junction temperature increases. Thus, at 45 °C the ratio may drop to around 20.

Under normal operating temperatures the sensitivity of the device is remarkable. For example, if a 2½V pea lamp is barely lit from a 1½V source, and the resulting small illumination is focused by a simple lens on to the sensitive area of the phototransistor over a distance of a few centimetres, the amplified current rises from the order of microamperes (the dark current) to in excess of 5 milliamperes! Thus, the usefulness of the phototransistor as a light-sensitive element can be appreciated.

SWITCHING CIRCUITS

Fig. 2 shows a simple switching circuit using the Mullard OCP71 phototransistor. Extra sensitivity and temperature compensation is given by the use of a transistor d.c. amplifier following the phototransistor, as shown in Fig. 3. Both of these circuits lend themselves to considerable experimentation to suit specific applications. The base resistor can give a degree of temperature compensation if of the negative temperature coefficient type. The actual value is best determined experimentally to suit both the conditions of maximum temperature and the light level. However, a component in the order of 5 kilohms is suitable for most applications.

The relay should have a coil of about 5 kilohms and it should pull-in at a power of about 5mW for reliable operation.

PHOTOCONDUCTIVE CELL

The photoconductive cell is essentially a resistive element made of cadmium sulphide which has the property of decreasing greatly in resistance when subjected to illumination. In complete darkness the resistance is in the order of 10 megohms and this can drop to as low as 75 ohms when the cell is fully illuminated. This very large dark-to-light resistance ratio means that the cell is extremely sensitive. More so, in fact, than the phototransistor.

The cell, which is often called a light-sensitive resistor (l.s.r., for short), is made by Mullard in three versions. There is the ORP12, which has maximum response in the red region and is intended for general purpose industrial applications and automatic contrast and brightness control in television receivers. This has a maximum limit of power dissipation of 200mW up to 40 °C. At higher temperatures the allowable dissipation reduces progressively to zero at 60 °C.

The RPY15 (formerly called the ORP15) has a maximum power dissipation of 400mW at 25 °C and is thus more suitable for applications where power is an important factor.

A low power unit is the RPY14. This has a maximum dissipation of 20mW at 25 °C and is designed essentially for exposure meters and automatic camera applications.

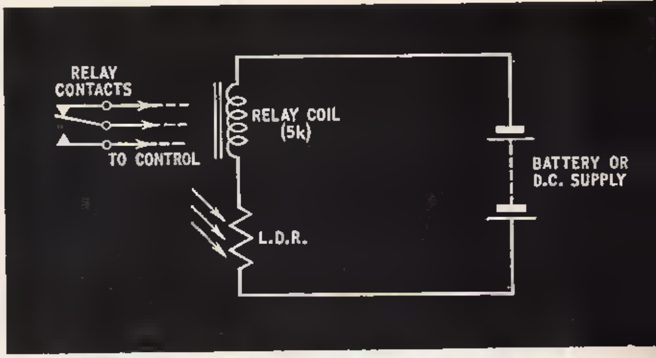

Fig. 4. A photoconductive cell (light-dependent resistor) can be arranged in this simple circuit to provide an effective light-operated switching action

The l.d.r. has several advantages over the phototransistor for certain applications. For one thing, the sensitivity that itself can convey to a control circuit is greater than that of the phototransistor. The larger versions can dissipate a greater power than the phototransistor, the collector dissipation of the OCP71, for instance, being limited to 100mW at 25 °C (50mW at 45 °C). Moreover, the l.d.r. can operate over a wider range of potentials than the phototransistor including operation at a.c., and polarity is not important. It can be arranged in a simple series circuit, as shown in Fig. 4.

SIMPLE L.D.R. CONTROL CIRCUIT

Here the l.d.r. is shown connected in series with a 5 kilohm relay coil and a 12V d.c. supply. If the relay is adjusted to pull-in at about 12mW (e.g. at a current of a little over 1·5mA), a very sensitive light-operated switching device can be evolved from the simple circuit. For reliable results, however, a sensitive relay is desirable.

A more robust Post Office type relay can be utilised by following the simple l.d.r. circuit with a transistor d.c. amplifier, as shown in Fig. 5. Here the l.d.r. is caused to change the base bias of the OC72 transistor and thus give an increase in collector current (and hence, relay current) when the resistance of the l.d.r. drops under the influence of illumination.

continued on page 115

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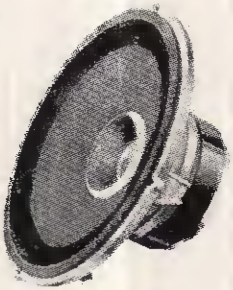

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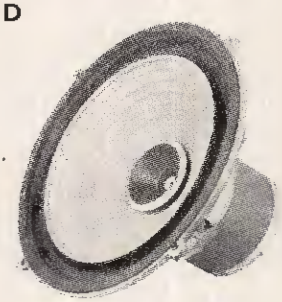

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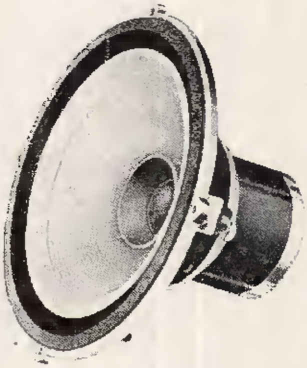

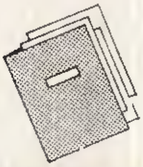

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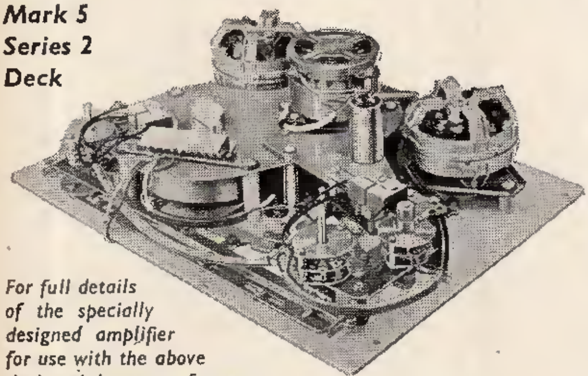

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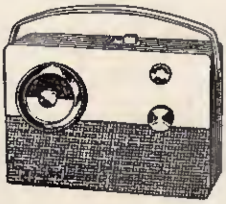

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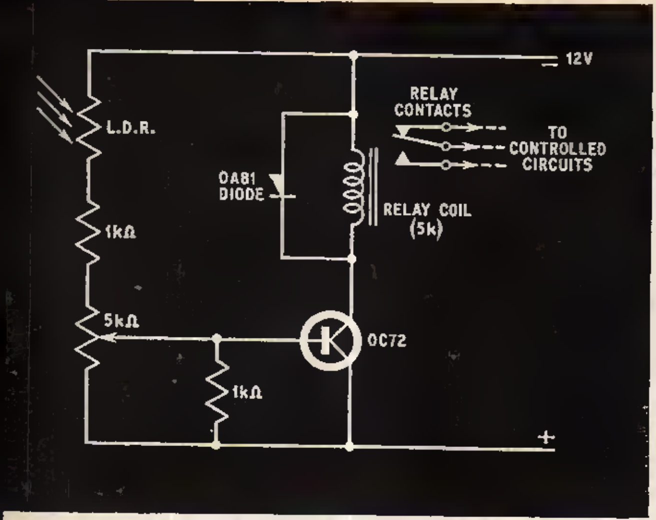


Fig. 5. A d.c. transistor amplifier following the l.d.r. allows the use of a more robust relay and provides a facility for sensitivity adjustment

The 5 kilohm potentiometer is used to adjust the base bias to give the required light/dark sensitivity conditions. Note that the diode across the relay winding in Figs. 2, 3 and 5 is to suppress the voltage surges which are otherwise likely to develop across the coil and damage the transistor during the switching cycle.

Several light-operated switches of the nature of those described in this article have been built by the author, and one application which has not yet been mentioned is for the measurement of speed.

This application is useful at race meetings of all types. At the finishing post a beam of light is arranged to cross the track and hold-on a relay of a light-operated switch. Now, when this beam is broken by the winner passing the finishing post, the relay switch changes over and operates a mechanical arrangement which stops a timing watch or other type of timer. Thus, provided the timing device is started when the race commences (this can be arranged automatically as well if needed) the winner himself stops the timing, and the actual time taken can be read off the dial in the ordinary way.

The experimenter in electronics will almost certainly find many other applications for the circuits described in this article. ★

PRECISION DECIMAL STEP PRE-AMPLIFIER

continued from page 109

rapidly while again applying the iron, to clear the hole of solder before inserting the new component.

It is advisable to use a miniature pencil-bit iron, e.g. of the 6 volt 10 watt variety. The copper strips on the cards take solder extremely rapidly and readily, so that it is possible to work quickly enough to prevent damage to transistors.

In the diagrams, Figs. 2, 3, 4, and 5, the rear copper strips have been numbered 1 to 16 from left to right as viewed from the front (components side) of the cards, and the 21 holes along any strip have been lettered A to U commencing from the socket end. Any hole can thus be specified by the corresponding number and letter combination. Where straps are shown between two holes these are simply short pieces of bare tinned copper wire cross-connecting different copper strips. Some of these straps are also located on the rear side, directly over the copper strips, as shown in Fig. 3 and Fig. 5.

The copper strips are to be interrupted at all the specified holes on the rear side of each card. Messrs. Vero Electronics sell a special hand awl, Cat. No. VB3011, for this purpose. This consists of a wooden tool handle carrying a small drill shaft of somewhat greater diameter than the width of the copper strips. A blunt pin extends at the front end of the drill shaft and exactly fits the holes in the circuit card. The drill is therewith held central while it scrapes the copper strip away at the desired point.

The two circuit cards, together with their associated sockets, can be accommodated quite conveniently in a box measuring approximately 8in by 5in and 2¼in deep. Fig. 7 shows the arrangement of the items inside the box and also details the interboard wiring.

Next month: the concluding part of this article will discuss some of the principles involved in the design of this pre-amplifier; factors which determine the input impedance will be explained and practical information given for adjusting this to some other value

Contributed Articles

The Editor will be pleased to consider for publication articles of a theoretical or practical nature. Constructional articles are particularly welcome, and the projects described should be of proven design, feasible for amateur constructors and use currently available components.

Intending contributors are requested to observe the style in our published articles with regard to component references on circuit diagrams and the arrangement of the components list.

The text should be written on one side of the paper only with double spacing between lines. If the manuscript is handwritten, ruled paper should be used, and care taken to ensure clarity, especially where figures and signs are concerned.

Diagrams should be drawn on separate sheets and not incorporated in the text. Photographic prints should be of a high quality suitable for reproduction; but wherever possible, negatives should be forwarded.

The Editor cannot hold himself responsible for manuscripts, but every effort will be made to return them if a stamped and addressed envelope is enclosed.

Ultrasonic Remote Control...

Remote control of apparatus is possible over distances upwards to 20 feet with this simple transmitting and receiving equipment.

The transmitter is housed in a popular type of torch case and is indeed as simple to operate as a normal electric torch. Just point the transmitter at the receiver, switch on and the ultrasonic beam radiated will be picked up by the receiving transducer, converted into electrical energy, and applied to operate a relay.

Unlike radio wave transmission, this "wireless" control system does not require a G.P.O. licence or other official sanction before it can be used.

APPLICATIONS

Apart from the obvious novelty value this ultrasonic equipment has certain very practical applications. We can only mention a few, but other applications will occur to many readers.

Remote channel selection on television receivers is possible if an electrically operated channel selector switch is fitted in the receiver. This switch would move one position for each pulse sent out by the transmitter. Radio receivers with preset tuning could be similarly controlled.

Any mains powered equipment could be brought into operation from a distance. For example, garage doors could be operated from inside a car, if the necessary electro-mechanical equipment is installed in the garage.

Although the effective range of the equipment as described in this article is 20ft maximum, some hints are given for increasing this upwards to 100ft for those who may wish to experiment further with ultrasonic remote control.

TRANSDUCERS

Two identical Gulton type 1404 ultrasonic transducers are used in this equipment. One functions as a transmitter—radiating pressure waves at a frequency of 40kc/s. The other transducer operates in the reverse manner converting the pressure waves back to electrical energy. The two units may be freely interchanged between the transmitter and the receiver.

Transducers should be bought as a pair, since it is important that their nominal frequencies be the same within ± 500c/s.

TRANSMITTER CIRCUIT

A pair of OC71 transistors are used in a feedback oscillatory circuit, this is shown in Fig. 4. The transducer X1 is connected in the feedback loop and provides a high Q circuit with a resonant frequency of 40kc/s.

Power for the transmitter is obtained from a miniature 9V battery (PP3 or DT3). The current consumption is 4mA.

RECEIVER CIRCUIT

A transducer of identical type to that used in the transmitter is incorporated in the receiver, see Fig. 1. A voltage is developed across this transducer X2 when it is subjected to pressure waves. This voltage is applied to the base of the first amplifying stage TR3. The collector of this transistor is directly coupled to the base of TR4 and the gain of these two stages is stabilised by means of overall negative feedback.

The signal is passed on via C2 to another two-stage directly coupled amplifier consisting of TR5 and TR6. Negative feedback is used here also to maintain constant gain. A tuned transformer T1 couples TR6 collector to the output stage TR7. This transformer is tuned to 40kc/s and ensures optimum sensitivity as well as providing rejection of other ultrasonic signals.

A relay RLA is connected in the collector circuit of TR7, and this becomes energised when TR7 is switched on by a signal passed on from the preceding stages of the receiver. The single-pole, make-break contacts of RLA can be used to switch power supplies or to operate other circuits in the apparatus it is intended to remotely control.

A 9V battery supplies the receiver. The consumption is 8mA.

RECEIVER CONSTRUCTION

All components for the receiver are accommodated quite easily on a laminated plastics board measuring 4in × 4½in. The prototype model described and illustrated here was built on a piece of Veroboard. It is not essential of course to use this particular material and if preferred a similarly sized piece of laminated plastics or even hardboard could be employed.

In such a case the components could be secured to terminal posts consisting of short pieces of 18 s.w.g. tinned copper wire inserted through holes drilled in appropriate positions (see Fig. 3). Use a drill slightly smaller than the wire to ensure a tight fit. Push the wire through the board until about ¼in emerges then cut off leaving a similar length protruding at the other side. Wire up the posts on one side of the board to agree with the diagram in Fig. 2 before mounting the components on the other side.

If the Veroboard is being used, remember to break the copper strips where indicated (see Fig. 2).

The relay coil is held in position by two loops of wire which pass through holes in the board.

INSTALLING THE RECEIVER

Mounting or housing arrangements for the receiver assembly will depend upon the application requirements or personal choice.

Generally speaking, it will be convenient to mount the receiver unit adjacent to the apparatus being controlled, or even within the same cabinet as for example in the case of a radio or television receiver. In this way the wiring from the relay to the controlled circuit is kept short.

The transducer must be mounted in such a manner that it will "look" directly towards the transmitter when the latter is brought into operation. If a 0·937in diameter hole is drilled in the front of the cabinet or container, the transducer can then be pushed through so it is flush with the front surface. If the cabinet material is not sufficiently thick to permit this method being adopted, a hole approximately ¾in diameter should be drilled and the transducer secured to the inside surface by means of a clip or bracket.

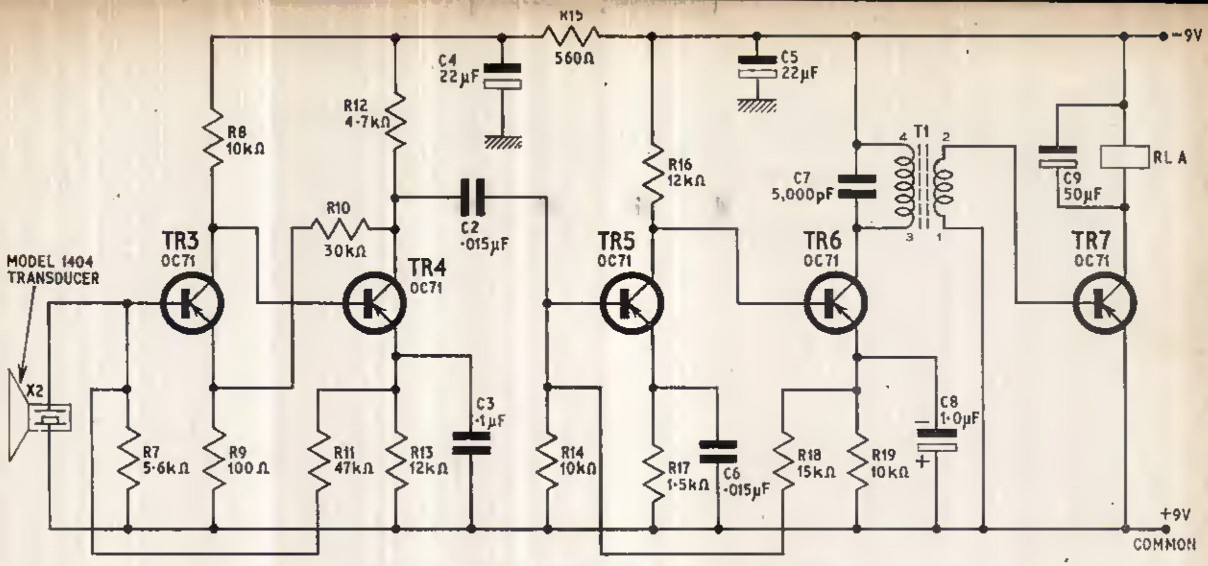


Fig. 1. The ultrasonic receiver circuit diagram

When wiring up the relay contacts to the controlled apparatus, ensure that these connections are well insulated and isolated from the components and wiring of the ultrasonic receiver.

The relay contacts have the following maximum ratings:

Power	15W
Current	1A
Voltage	250V

Contact resistance is 0.05 ohm and the actuate time is 2msec.

TRANSMITTER CONSTRUCTION

The transmitter uses few components and the circuit is quite simple. However, due to the compact form of its assembly a certain amount of dexterity is called for during construction.

No insurmountable problems should arise if a torch case of the type and size specified is obtained. A larger torch case could be used if so desired; it would be necessary then to increase the width of the component panels to ensure a good fit in the case.

The first task is to prepare two small pieces of Veroboard as shown in Fig. 5.

Next mount the resistors and transistors in position on each board. The most tricky operation comes next. Solder one end of C1 to the (inner) side of panel A, at the point indicated in Fig. 5. Carefully manipulate the other lead on this capacitor to allow this to be soldered to panel B as indicated. Finally, secure this sandwich assembly by inserting short lengths of 20 s.w.g. tinned copper wire through facing holes in the two panels at the four positions 1A, 4A, 1J and 4J.

Initially solder these four wires to one panel only. Carefully adjust the position of the panels until there is a separation of $\frac{1}{4}$in between their inner surfaces, and then solder the other ends of the four wires to secure

Fig. 2. The copper strips on the receiver Veroboard must be cut as indicated

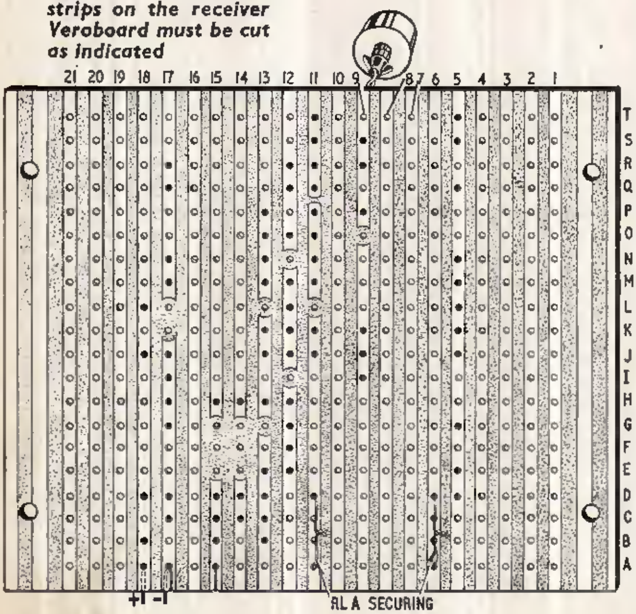
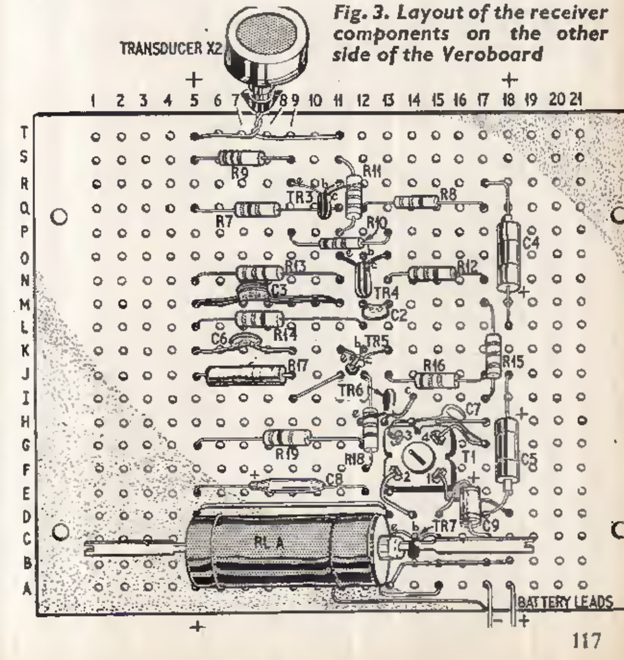


Fig. 3. Layout of the receiver components on the other side of the Veroboard



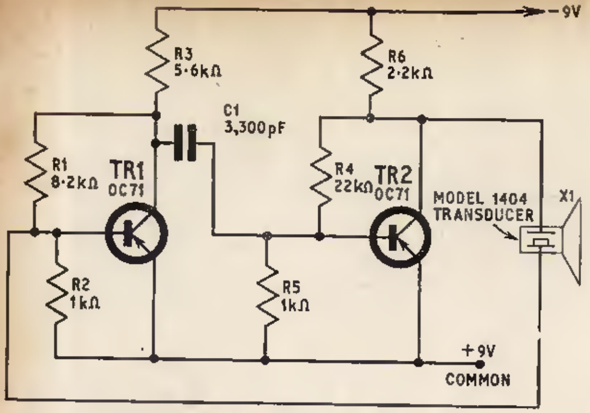


Fig. 4. Circuit diagram of the transmitter

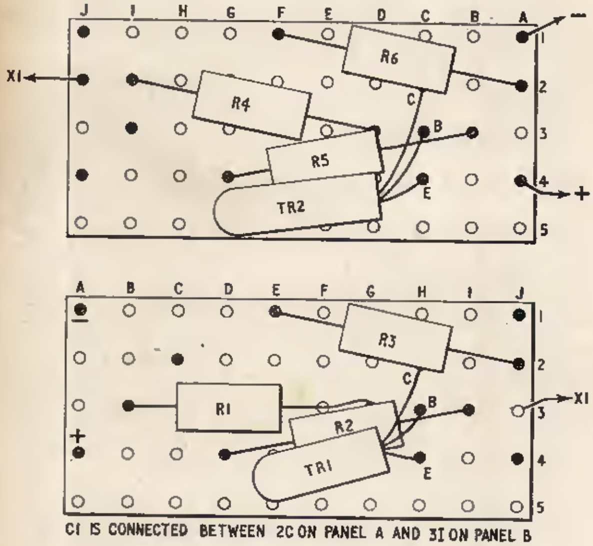


Fig. 5 (above, left). The transmitter panels showing the arrangement of components. Panel B is above; Panel A below. Each panel measures 1½in by ¾in

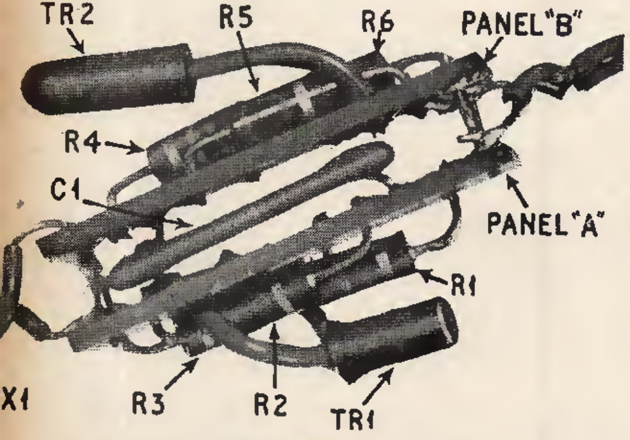


Fig. 6 (above). The transmitter assembly ready for insertion into the torch case

the whole assembly. The completed assembly is illustrated in Fig. 6.

Connect two insulated flexible leads to the miniature coaxial plug, twist these leads and cut off leaving a 1in length. Solder the free ends, one to panel A and the other to panel B as indicated "to × 1" in Fig. 5.

Connect a lead of about 3in length to the linking wire A1 as indicated in Fig. 5. Use blue coloured plastics covered flexible multi-strand wire. Single conductor leads are not at all suitable for this purpose—since their rigidity will inhibit the manoeuvres that are involved in the assembly process, and will probably result in breakages occuring at soldered connections.

TORCH CASE

A "Vesta" plastics torch case available at many multiple stores is used in this design. This particular case is made in a variety of colours, it is 5¾in long and has an internal diameter of 1in.

Remove the top cap from the torch case. Take out the glass, bulb, and reflector; these items are discarded.

Examine the switch mechanism. The brass tongue which protrudes towards the top of the case must be cut off as far down as possible. This can be performed with a pair of tin snips. Solder a (red coloured) plastics covered flexible lead to the stub and bring this lead down and out through the bottom of the case. Refer to Fig. 7. A small instrument type iron is essential, and care must be taken not to allow the bit to make contact with the plastics case. Place the transmitter assembly inside the lower portion of the case, but with its end protruding slightly.

Connect the red lead from the switch to point A4. Now gently push the assembly up inside the case until the coaxial plug emerges at the top. Fit the transducer to this connector. Refit the plastics top cap.

Move the assembly back down the case (applying *slight* pressure on the transducer face at the same time pulling *gently* on the blue battery wire) until the face of the transducer is level with the top edge of the torch cap.

continued on page 146

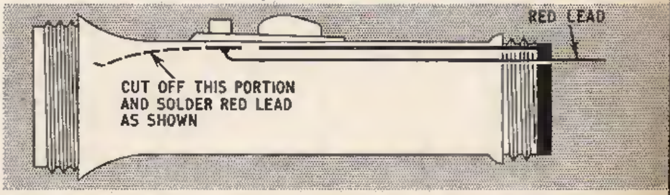
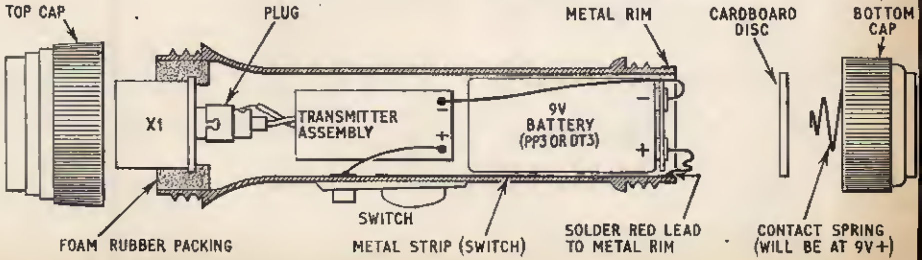


Fig. 7 (above). Modification to the torch switch

Fig. 8 (below). A sectional view of the torch case with the transducer, transmitter assembly, and battery installed



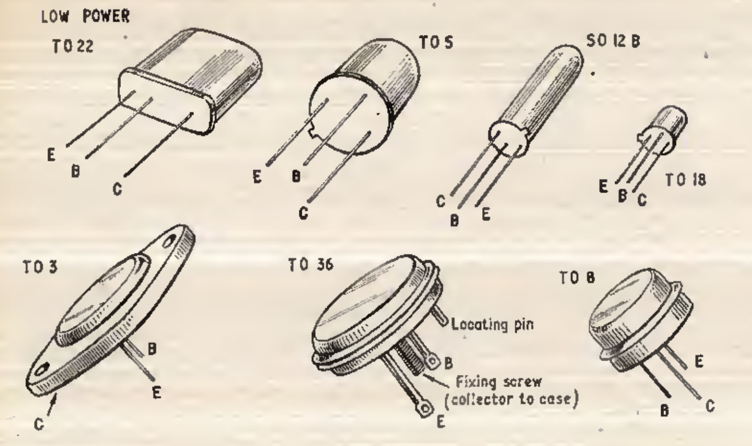


***Fig. 16.* Some typical transistor encapsulations from the Newmarket range**

TRANSISTOR *DO*s AND *DON'T*s

DO:

1. Check polarity (*npn* or *pnp*).
2. Check battery supply polarity.
3. Identify leads correctly.
4. Ensure correct type.
5. Ensure whether transistor should be insulated from chassis.
6. Ensure contact of the faces of power transistors are smooth and that thermal contact with the heat sink is efficient.

DON'T:

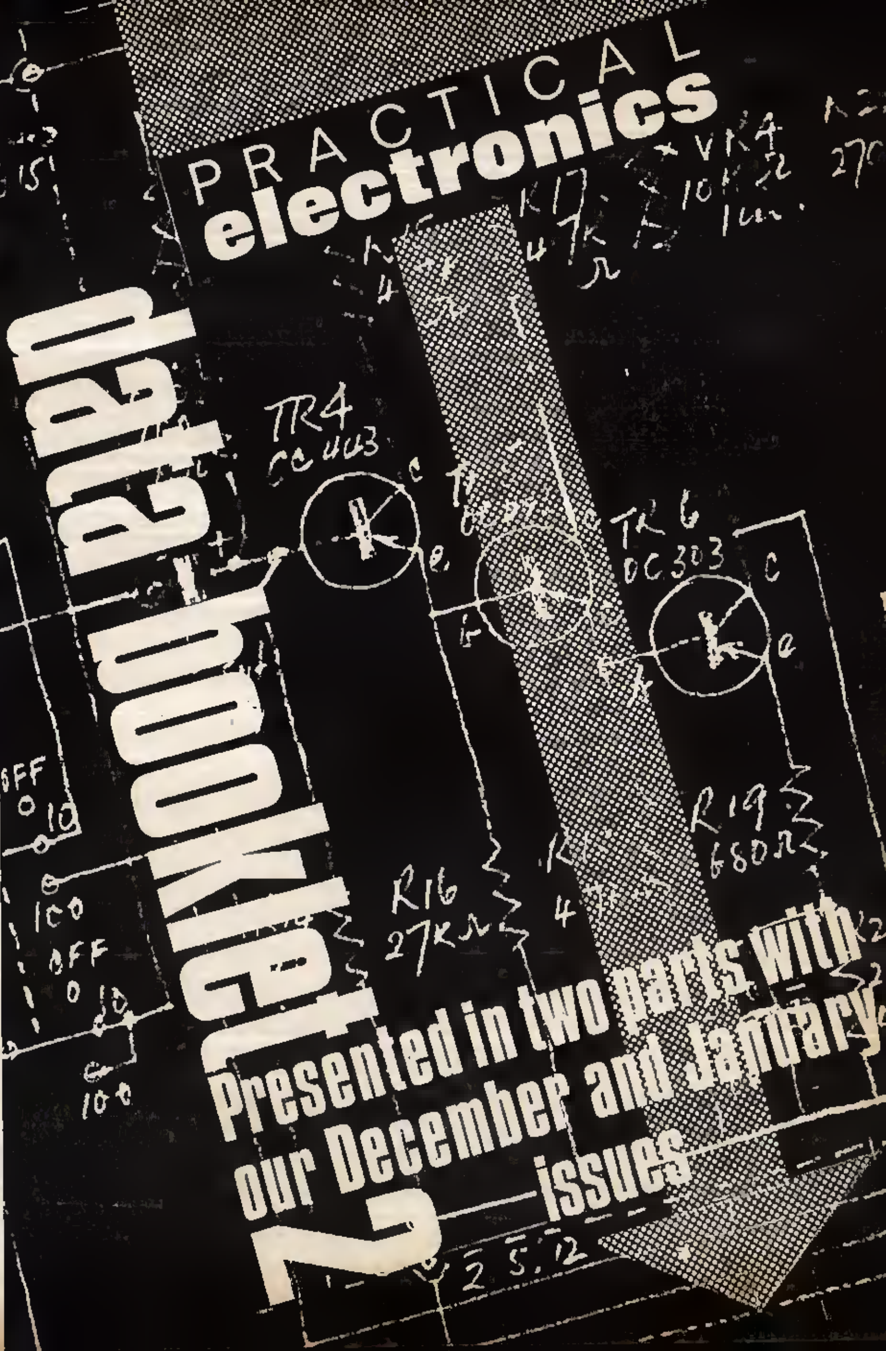
1. Bend leads too close to the seal.
2. Solder leads without heat shunt.
3. Apply heat too long.
4. Mount in or near strong magnetic or electrostatic fields.
5. Operate transistors above maximum ratings.
6. Use "quick heat" gun type soldering irons.

Useful Tips

1. Silicone grease smeared on the surfaces in contact with the heat sink will increase heat conduction.

2. Black matt heat-resistant paint used on heat sinks and transistors helps dissipation of unwanted heat.

3. Long nose pliers, or a crocodile clip with two copper slugs soldered into the jaws, serve as heat shunts, when soldering into position. The heat shunt should be attached to the wire being soldered.



PRACTICAL
electronics

data booklet 2

Presented in two parts with our December and January issues

THERMIONIC DEVICES

Diode

Construction

The circuit symbol and typical construction of a diode are shown in Figs. 1 and 2, with indirect heating to cause electron emission from the oxide coated cathode. Less common now is the method of direct heating where the cathode (often made of tungsten wire similar to an electric lamp filament) is directly heated by passing a current through it.

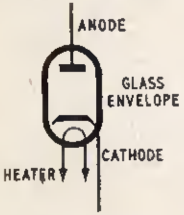


Fig. 1. **Circuit Symbol**

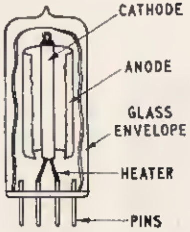


Fig. 2. **Construction**

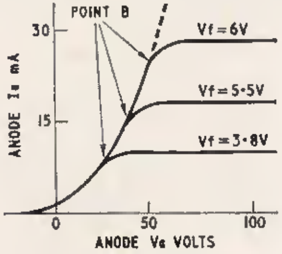


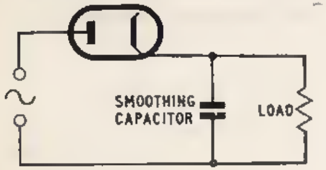
Fig. 3. **Characteristics**

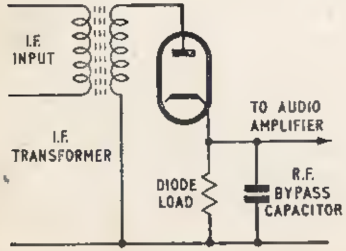
Theory

The curves of the characteristics in Fig. 3 conform to a definite law where the current through the valve $I_a = V_a^{3/2}$ and is known as the "threehalves law" up to point B on the curves. Above point B saturation occurs where all the electrons in the space charge around the cathode are being drawn to the anode and no further increase in anode current is possible for a given heater voltage V_f.

Applications

Diodes are used in numerous circuits some examples of which are shown in Figs. 4, 5, and 6.





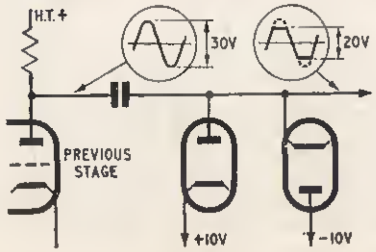


Fig. 4. **A.C. rectification (left)**
Fig. 5. **Detection (below left)**
Fig. 6. **Signal Limiting (below)**

Basic Configurations

The circuits in Fig. 15 show the three basic configurations in which transistors are used and the table gives some typical characteristics and parameters of low power transistors.

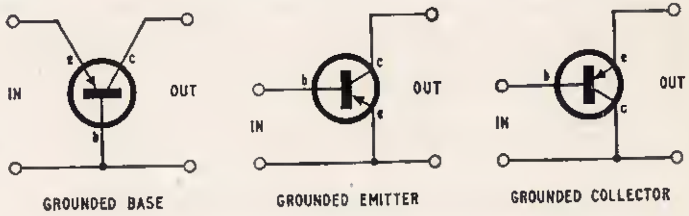


Fig. 15. **Basic transistor configurations**

	Grounded Base	**Grounded Emitter**	**Grounded Collector**
INPUT SIGNAL TO	Emitter	Base	Base
OUTPUT SIGNAL FROM	Collector	Collector	Emitter
CURRENT GAIN	approx. 1	approx. 50	approx. 50
VOLTAGE GAIN	High (approx. 160)	High (approx. 160)	Low (approx. 1)
INPUT IMPEDANCE	Low (200Ω)	Medium (1000Ω)	High (100kΩ)
OUTPUT IMPEDANCE	High (200kΩ)	Medium (40kΩ)	Low (1000Ω)
POWER GAIN	Medium (30dB)	High (40dB)	Low (16dB)
H.F. RESPONSE (POWER = 3dB DOWN)	High (400kc/s)	Low (12kc/s)	Dependant on Load resistance
PHASE SHIFT	0 deg (output in phase with input)	180 deg (output inverse to input)	0 deg (output in phase with input)

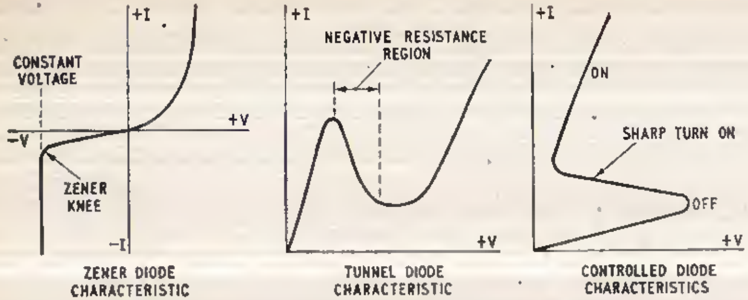


Fig. 13. Characteristics of special purpose diodes

Transistor

For the purpose of this booklet *pnp* transistors only will be considered but the information given will also apply to *npn* types except that biasing and h.t. supplies have reverse polarity d.c. voltages applied.

The addition of an extra element to the junction diode, *p*-type material in the *pnp* transistor and *n*-type in the *npn* transistor produced a device capable of amplification. In practice the *n*-type material in a *pnp* transistor is extremely thin. Typical constructions of some transistors are shown in Fig. 14.

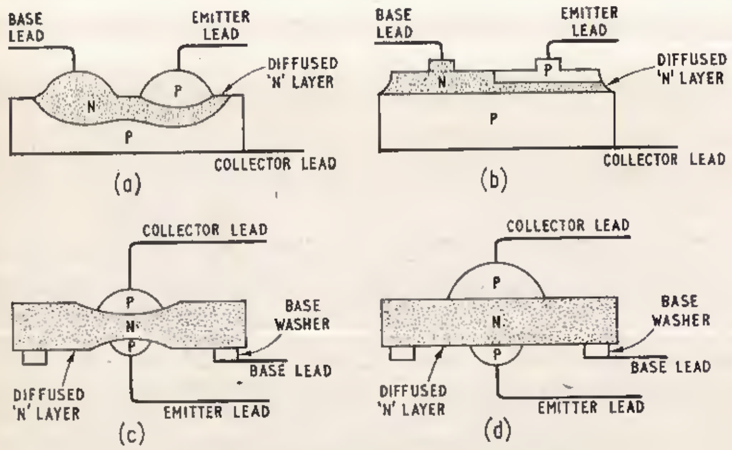


Fig. 14. Transistor construction methods
(a) post alloy diffused (p.a.d.t.) *(b) 'MESA' type*
(c) microalloy diffused (m.a.d.t.) *(d) 'Drift' type*

Triode

De Forest found that the addition of a third element or electrode (called a grid) to the diode placed close to the cathode relative to the anode enabled a small variation of voltage on the grid to produce a large variation of anode current. This discovery and its development precipitated a technological revolution, the implications of which the world still hasn't fully realised.

Construction

The varieties of triode types are too numerous to be treated fully by this booklet but a typical receiving triode, the construction of which is common to all types, is shown diagrammatically in Fig. 8. The grid can be seen to be a form of spiral wire. The electrons pass from cathode to anode through the spaces between each turn of the coil.

Theory

The characteristic curves given in Fig. 9 of anode current against anode voltage for various values of negative grid voltage are similar to those for the diode except that the grid voltage is the third parameter.

From the characteristics it can be seen that as the grid voltage is made more negative the anode current is eventually reduced to zero. It is this variation of anode current with grid voltage that produces amplification and is known as mutual conductance. The change in voltage across a load resistor, placed in series with the valve anode and h.t. positive rail, is greater than the change in grid voltage that produced it. More detailed information on this principle is given in the centre portion of this Data Booklet to be given with the January issue of PRACTICAL ELECTRONICS.

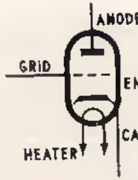
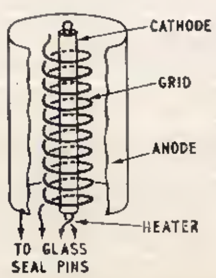
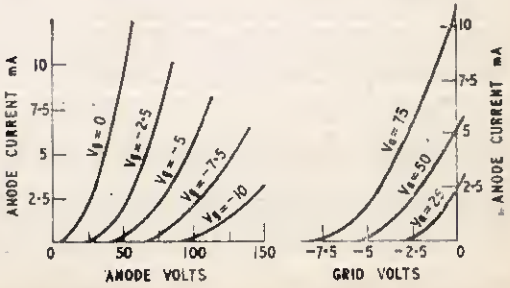


Fig. 7. Triode circuit symbol (left)

Fig. 8. Triode construction (below left)

Fig. 9. Triode characteristics (below)





Applications

The applications of triodes are as varied as the different types, but generally speaking triodes are usually found in stages where a low noise factor is more important than high amplification or high frequency response. At high frequencies triodes become less effective due to the shunting effects of interelectrode capacitance, especially the capacitance between anode and cathode, known as the Miller Effect.

At very high frequencies special triodes are used which have very low capacitance. Special triodes are used in some transmitter circuits but neutralisation of the interelectrode capacitance by "external" means is still necessary.

In the tuner sections of television circuits an arrangement is often used whereby the anode load of a triode r.f. amplifier is in the form of another triode circuit with its grid grounded to a.c. This arrangement is known as a "cascode" amplifier; the grounded grid prevents feedback of the amplified signal and so reduces the Miller Effect.

Tetrode

The tetrode as its name suggests is a triode with an extra electrode interposed between the grid and anode. The fourth electrode is known as the screen grid and is held at a steady voltage approaching that of the anode, providing extra amplification and greater mutual conductance.

In the characteristics shown in Fig. 10, a region of what is known as "negative resistance" occurs due to the secondary emission of electrons from the anode resulting in the repulsion of electrons arriving at the anode from the cathode.

This condition is normally a disadvantage in most applications and is avoided. However, it has been found that it can be usefully employed in some types of oscillator.

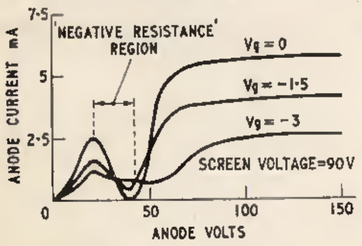


Fig. 10. Tetrode

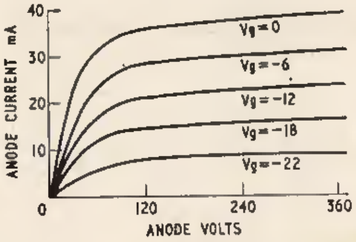


Fig. 11. Pentode

Pentode

The pentode has a fifth electrode interposed between the screen grid and anode and is normally held at cathode potential. Its function is to increase the effective working portion of the characteristic available by reducing secondary emission from the anode (Fig. 11). The "negative resistance" region described in the tetrode section is eliminated.

Continued on page 13

Continued from page 4

Other Types of Valves

Further additions of electrodes are often provided to facilitate the function of two or more valves inside one envelope. One example of this is the triode-hexode arrangement of the superheterodyne receiver. The triode section is the local oscillator while the hexode (six electrodes) is the r.f. amplifier. The two stages are combined to form the mixer, the resulting signal being passed on to the intermediate frequency amplifiers.

★ ★ ★

SEMICONDUCTOR DEVICES

The use of semiconductors dates back many years, in fact the "crystal and cat's whisker" device was probably the earliest type used. Later developments led to the "fixed" point contact diode which was found to be more reliable in radar applications during the Second World War. The outcome of post-war work led to the discovery of techniques for producing germanium junction diodes and triodes.

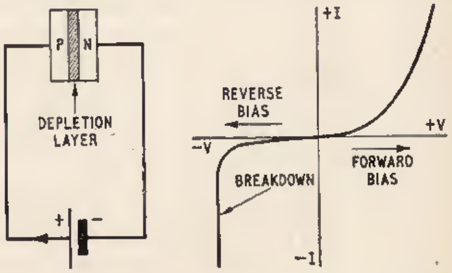
It is not intended to deal with point contact devices fully in this booklet due to their obsolescence. The physics of semiconductor devices has also been omitted because such information is adequately covered by many authoritative text books.

The main advantages of semiconductor diodes over thermionic diodes are:

(i) no heater power is required;
(ii) smaller physical size;
(iii) lower forward voltage drop.

The theoretical diagram of a *pn* junction is shown in Fig. 12 with typical forward and reverse biasing characteristics.

Fig. 12. Basic circuit and characteristics of a semiconductor diode



Further developments of the junction diode have produced unique devices such as the Zener diode, tunnel diode, silicon controlled rectifier, and gate controlled rectifier. Some of their characteristics are shown in Fig. 13.

INTEGRATED TRANSISTOR AMPLIFIER

FULL DETAILS ARE GIVEN HERE OF THE POWER AMPLIFIER SECTION

Six transistors are employed in the power amplifier, the circuit of which is shown in Fig. 6. The first transistor, TR5, is connected as an emitter follower, the collector being grounded to a.c. by the 32μF capacitor C15. This mode of operation gives high current gain and zero phase shift between input and output, a good match therefore exists for practically any type of input. Stabilisation is achieved by C14 across the bias network.

The output from the emitter of the first stage is directly coupled to the high gain stage TR6. C17 assists in reducing the high frequency rising characteristic of this stage. The collector of this stage is directly coupled to the base of the phase reversing *npn* transistor TR8 and via D1 to the base of TR7.

SPECIFICATION

Frequency response
Substantially flat from 20c/s to 25kc/s
Sensitivity
An input of 50mV is required for full drive
Overall feedback
17dB
Output Impedance
Less than 1 ohm
H.T. Supply
28V normal, 32V maximum
50mA quiescent. 500mA for full sine wave output
Battery Operation
When powered by a 9V battery, an output of 300mW is obtainable

TR7 and TR8 operate in the class B Darlington mode to increase current gain. This again has the advantage of push pull emitter follower operation. It will be noted that each stage is directly coupled throughout the amplifier; there is therefore no phase shift or frequency losses due to capacitive coupling.

FORWARD BIAS

The output transistors TR9 and TR10 have a small forward bias to minimise crossover distortion. This bias is set by the voltage drop across the 1 kilohm resistors R26, R27 which are in parallel with their input. Capacitors C18, C19 are connected across these resistors and stabilise the circuit reducing the drive some 70 per cent at 30kc/s.

Transistors TR7 and TR8 are biased for the same reason by the voltage drop across the OA10 diode D1.

FUNCTION OF THE DIODE

A 70 ohm resistor could be used in place of the diode D1 to serve the same function; a resistor would not, however, give any temperature compensation and the bias would be disturbed accordingly. True thermistors could be used to compensate for the

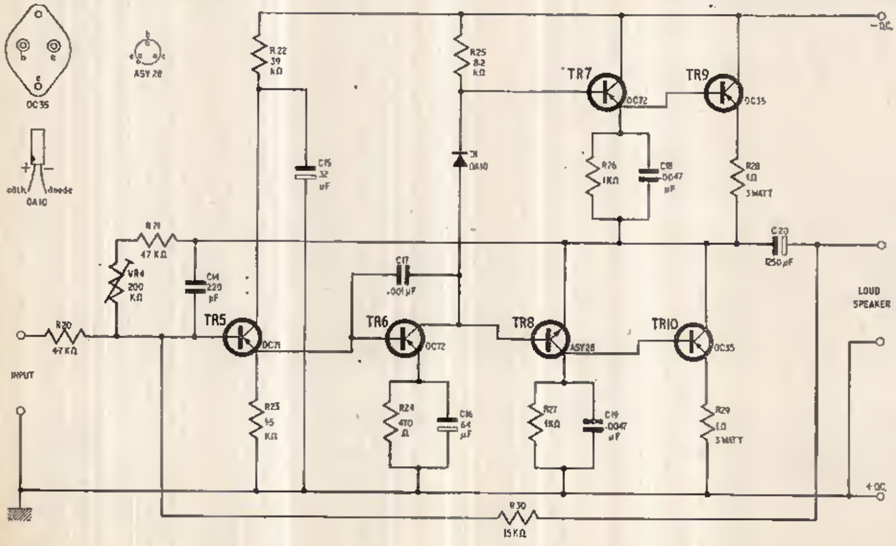


Fig. 6. Circuit diagram of the power amplifier with base details of transistors shown in the top left-hand corner of the drawing

temperature variation of the emitter base resistance, but their performance is not comparable with the OA10 diode which has characteristics similar to the germanium transistor.

Having explained the reason why the diode is used and its function in the amplifier circuit, it would be well to describe a precaution that must be observed in placing it in the circuit when constructing the amplifier.

The OA10 is a high current, low voltage germanium junction diode. It is important that no alternative diode is used in the amplifier and great care should be taken during construction that it is connected the correct way round in the circuit. The function of D1 is to assist in temperature stabilisation of the circuit and to couple the complementary pair TR9, TR10 in a correct push pull mode.

It is important that the base inputs to the driver transistors are never open circuit with respect to one another at any time. An equivalent condition arises should the OA10 diode be inadvertently reversed. If this happens the base of the driver transistor TR7 becomes more negative while the base of TR8 becomes more positive, moving towards the earth rail. The resulting large bias increase will cause the collector/junction resistance to become extremely low and the output transistors will then draw excessive current through the base in a matter of seconds resulting in collector to emitter short and the ruining of expensive transistors. (This is of course no different from connecting the grid of a thermionic valve to a 400V line.)

To enable the amplifier to be used with low-level sine wave testing, 1 ohm resistors are inserted in the emitter circuits of the output transistors, giving reverse bias and further aid to linearity.

The quiescent current is some 50mA rising to 500mA for full sine wave output.

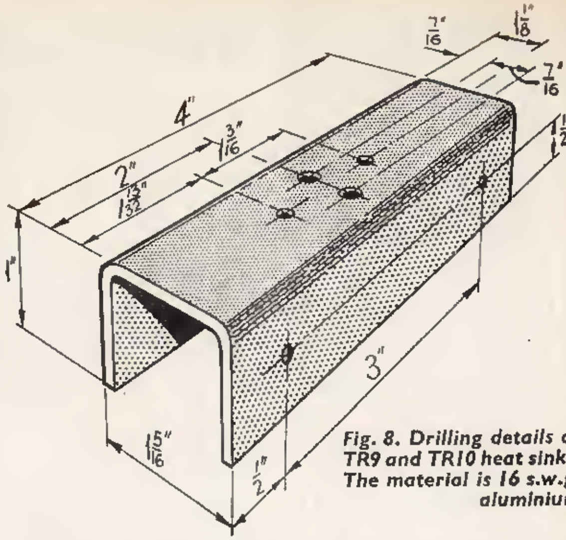


Fig. 8. Drilling details of TR9 and TR10 heat sinks. The material is 16 s.w.g. aluminium

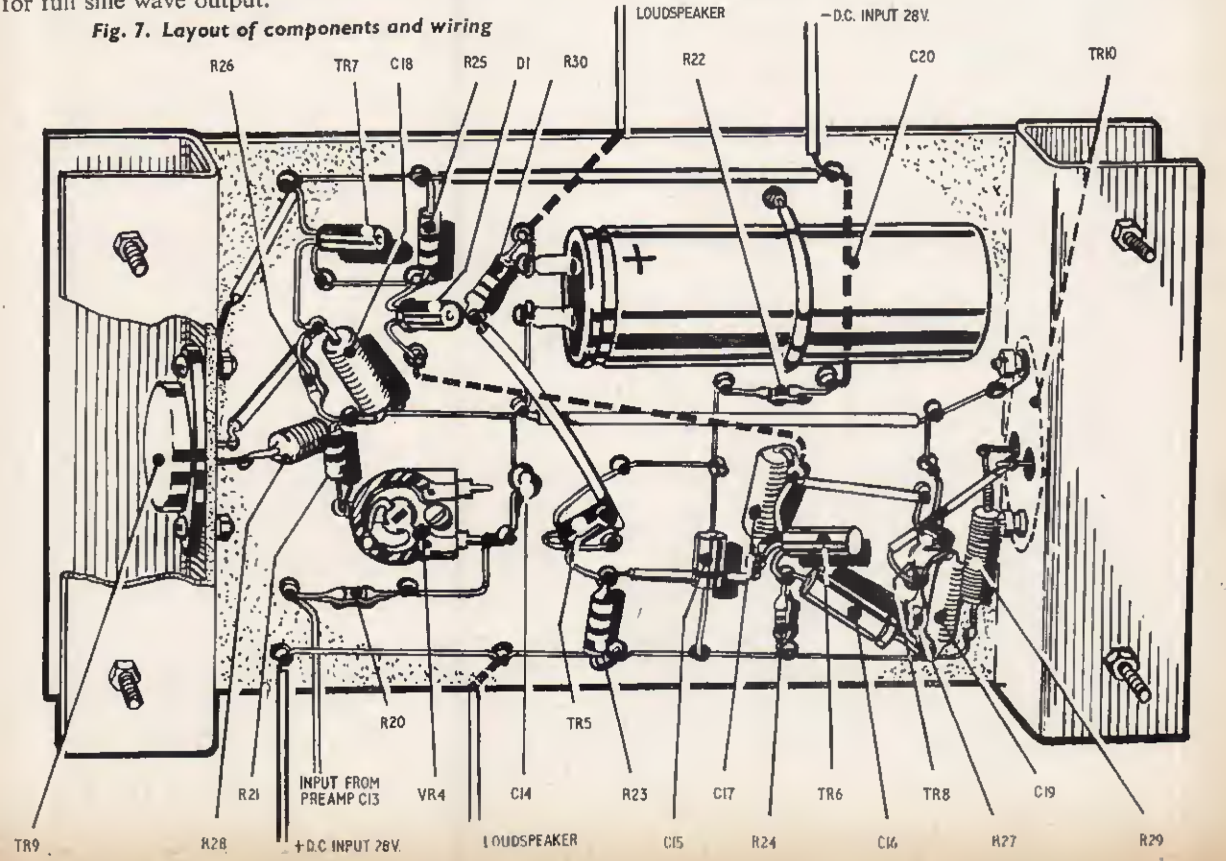
The h.t. is normally 28 volts with 32 volts maximum. The amplifier will perform quite satisfactorily at a reduced output of 300mW when supplied by a 9V battery.

Overall feedback of some 17dB is applied via the 15 kilohm resistor R30 from the amplifier output to the base of TR5.

CONSTRUCTION

Construction is straightforward and follows similar lines to that of the pre-amplifier, as described in last month's article. If larger components than those shown in the layout diagram (Fig. 7) are used, the

Fig. 7. Layout of components and wiring



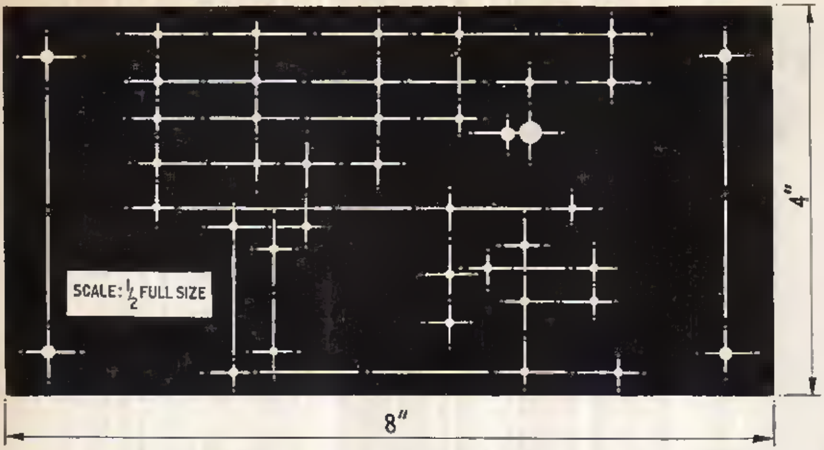


Fig. 9. Drilling details of the plastics board

circuit board (Fig. 9) may have to be enlarged accordingly, but providing the general layout arrangement is adhered to no difficulties should arise on this account.

There is no hum level to worry about and the whole unit is extremely stable.

The construction of the heat sinks is quite simple if the following procedure is adopted. Obtain a piece of hard wood 1½in square and 4in in length. From a sheet of 16 s.w.g. aluminium cut two pieces each measuring 4½in × 4in. Hold each piece in a vice and bend it round the mandrel to form a C channel heat sink. See Fig. 8.

In the centre section of each heat sink drill the holes for the power transistor fixing screws and the feed-through holes for the base and emitter connections. In the corners of each heat sink drill four holes for fixing the assembly boards into their final positions.

Special care must be observed when connecting the ASY28 *npn* transistor TR8. The collector looks towards the positive rail and the emitter towards the negative side of the output electrolytic C20. This is, of course, opposite to the connection of the OC72 *pnp* transistor TR7.

SETTING UP

When the power amplifier panel has been completed, check the connections carefully. A loudspeaker must be connected to the output terminals before power is applied to the amplifier. The output impedance of the amplifier is less than 1 ohm and ensures good loudspeaker damping. Any speaker having an impedance of from 3 to 15 ohms can be used.

If you have any doubts regarding the speaker impedance you propose using, remember a very easy way of finding the impedance is to measure the d.c. resistance and multiply this by $\sqrt{2}$. The power supply can be derived from either a battery or from a mains power unit giving a d.c. output of 32V.

The improved loudspeaker damping and absence of an output transformer (which is both costly and inefficient) are quite definite steps in the direction of true quality reproduction. Class B amplification has the advantage of low quiescent current and high efficiency at full output, the average current consumption on music being about one-third of that on maximum sine wave output.

BIAS ADJUSTMENT

In principle, the two output transistors should be biased to cut off; however, strict adherence to this condition results in crossover distortion which is most unpleasant to the listener. This serious disadvantage which takes the form of a thin reedy kind of noise, which at low input gives the impression of a displaced loudspeaker cone, can be overcome by applying a small forward bias to each transistor, as stated in the earlier description of the transistor functions stage by stage.

Any slight distortion discernable can be eliminated by careful adjustment of the variable voltage level control VR4 between the base of TR5 and emitter collector junction rail to TR9, TR10. The ease of this adjustment is only apparent when final setting up is taking place at a low volume of a piano recording of, say, Beethoven's "Moonlight Sonata". Once the correct position is set, no further adjustment is necessary.

CAUTIONARY NOTE

Do not attempt to use the amplifier at any time without a speaker or equivalent d.c. resistive load connected between the output capacitor C20 and earth. Always remove the d.c. supply before disconnecting the speaker: very large transient currents are built up in the large electrolytic capacitor and, if undamped by the low resistance of the speaker, will surge through the output transistors and damage them.

COMPONENTS . . .

Resistors

R20	4·7kΩ	R25	8·2kΩ
R21	47kΩ	R26	1kΩ
R22	39kΩ	R27	1kΩ
R23	1·5kΩ	R28	1Ω 3W
R24	470Ω	R29	1Ω 3W
		R30	15kΩ

All ⅛W, cracked carbon, high stability 5%, unless otherwise indicated

Potentiometers

VR4 200kΩ carbon preset (skeleton type)

Capacitors

C14	220pF ceramic	C17	1,000pF polyester
C15	32μF 10V	C18	4,700pF polyester
C16	64μF 10V	C19	4,700pF polyester
		C20	1,250μF 25V

All electrolytics, unless otherwise indicated

Transistors

TR5	OC71	TR8	ASY28
TR6	OC72	TR9	OC35
TR7	OC72	TR10	OC35

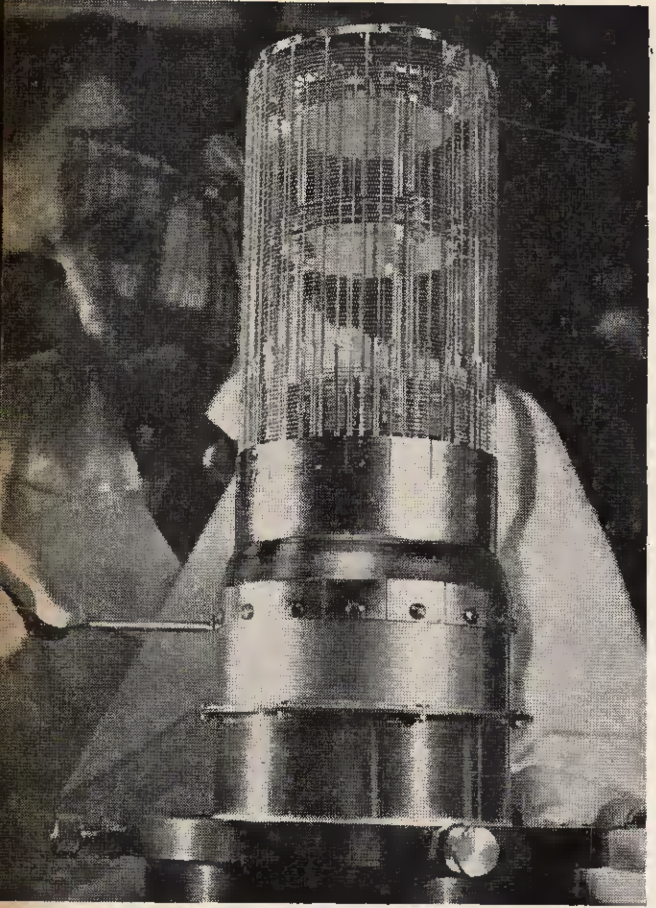
Diode

D1 OA10

The next and concluding article will describe a simple mains power supply unit giving 28V from a standard battery-charger transformer. This article will also include some advice on the stereophonic arrangements for those who are interested in stereo reproduction and do not mind the cost of duplicating the amplifier and pre-amplifier

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE



Valves Still Used Here! ▲

This gigantic device is a new 200kW power transmitting triode, shown by the English Electric Valve Company at the recent British Exhibition in Sydney. The picture shows the structure of the grid and filament.

"Early Bird" with Travelling Waves

The Post Office is installing water-cooled C-band travelling-wave tube amplifiers in the world's first commercial communications satellite system—"Early Bird". The tubes will give an operating power output of 10kW at 6,301Mc/s with a tuning range of the r.f. structure of 225 Mc/s and small-signal bandwidth better than 30Mc/s.

The satellite will be launched into a "stationary" position 22,000 miles above the Atlantic to provide a 24-hour link between North America and Europe. It will be able to transmit live television programmes or provide up to 240 two-way telephone circuits.

Olympic Relay

Syncom III satellite, which was used as a vital link for the transmission of television pictures of the 1964 Olympic Games, held in Tokyo in October, to Point Mugu in California, was not specifically designed for television transmission. The r.f. bandwidth of the satellite circuit, 13Mc/s, is insufficient to provide adequate bandwidth for a television signal with the high deviation f.m. system used. The video bandwidth of about 2·7Mc/s cannot be increased by reducing the deviation without degrading the signal/noise ratio. To overcome this problem a helical scan tape recorder was used in Tokyo.

Sound programmes were sent from Tokyo to Hawaii via the recently laid trans-Pacific telephone cable and thence to Vancouver by means of the Commonwealth Pacific telephone cable (COMPAC). Microwave radio links carried the signal across Canada to the Canadian transatlantic telephone cable (CANTAT) for linking to the British trunk telephone system in Scotland.

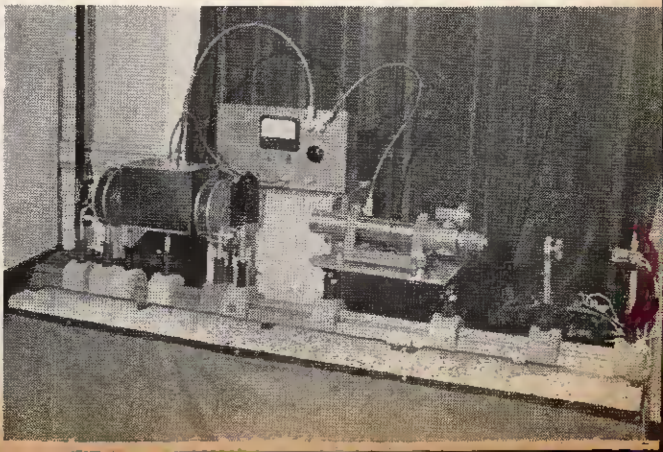
International Conference on Lasers

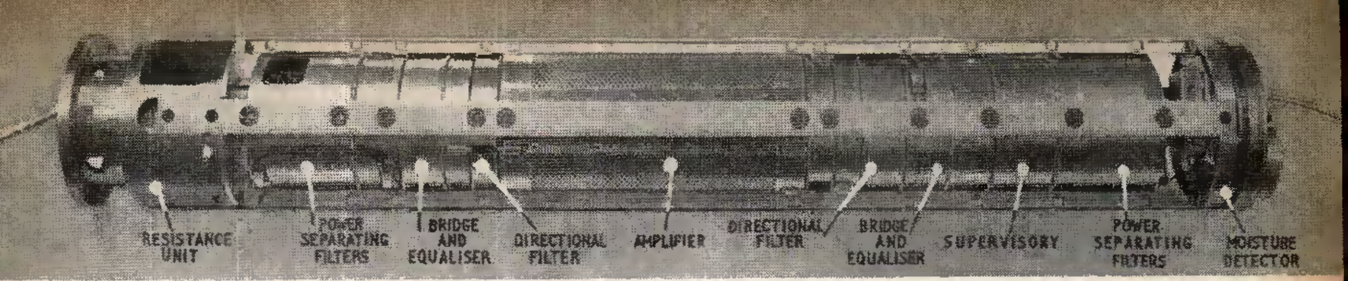
New possibilities in the fields of measurement and communication are being found by using lasers. The Conference on Lasers and their Applications, held at the I.E.E. in London in conjunction with the I.E.R.E. and the American I.E.E.E. in September, revealed some interesting advances in laser techniques.

The laser produces a very intense light beam with many properties, similar to radio waves, which ordinary light does not possess. Laser transmissions can be focused into very narrow beams enabling very long range and a high degree of accuracy to be obtained in rangefinding and communication applications. Laser beams can also be used for precision welding (see last month's issue) and cutting applications. It is envisaged that, due to the very high frequency which lasers provide, there is a possibility for virtually unlimited capacity for telephone and television transmissions.

The picture shows one application of the ruby laser exhibited by the University of Southampton as a bleaching agent for blue dye. When the laser is "pumped", oscillation first occurs with the dye absorbing. The ruby rod then sees the full reflectivity of the mirrors and Q-switched operation ensues.

▼



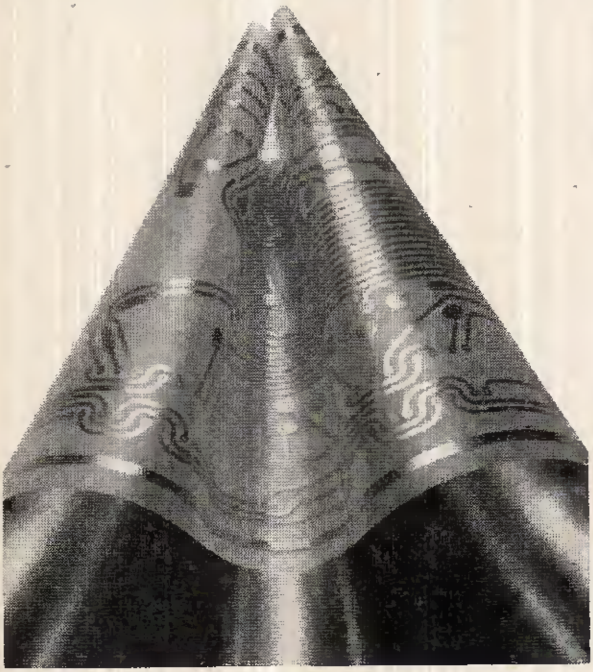


Denmark on the Dial!

THE FIRST high capacity telephone cable between Britain and Denmark was brought into service on 1 October to increase the number of telephone circuits between Britain and Germany, Denmark, and Holland. The cable, which is laid between Winterton in Norfolk and Esbjerg, will provide 120 high quality speech circuits.

This is the second of five cables planned to be laid across the North Sea by 1966. One of two to Germany was opened earlier this year. Two cables will be laid to improve the facilities to Holland. Twenty-four submerged repeaters are spaced evenly along the 300 nautical miles of cable to boost the speech signals. One of these is shown above giving a layout of the various units.

International subscriber trunk dialling will be introduced from Britain to Denmark in the spring.



The Shape of Circuits to Come?

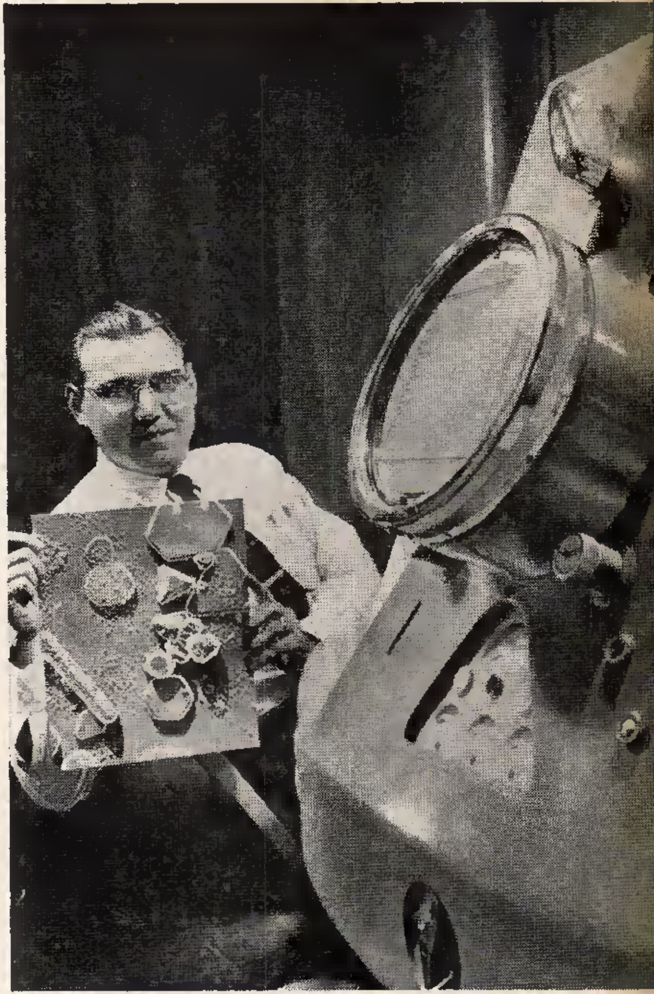
A NEW grade of copper-clad Bakelite laminated sheet has been developed for the preparation of printed circuits. The new grade is made by bonding copper foil to polyester film and may be coiled and folded. It could enable the size of an assembly to be considerably reduced. Processing is achieved in the normal way by etching or printing techniques.

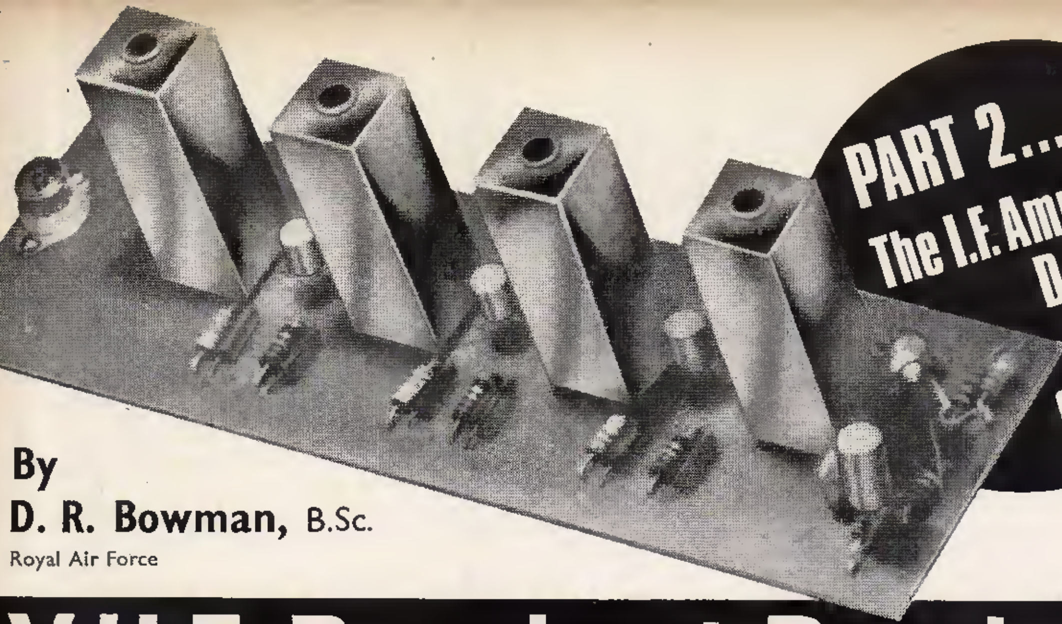
It is expected to find useful applications in automobile wiring, computers, telephone and switchboard wiring, radio and domestic appliances.

Electronics "See" Ten-millionth of an Inch

A RESEARCH chemist in New York has been using an electron microscope, which is capable of seeing particles one ten-millionth of an inch in size, to study the crystal structure of silver halides during chemical reaction.

The enlarged electron micrograph in the picture below shows what is happening to silver bromide crystals in a solution of potassium iodide as seen by the microscope at 30,000 diameters. The crystals are being dissolved by the potassium iodide as silver iodide (small crystals) is formed.





V.H.F. Broadcast Receiver

PART 2.... The I.F. Amplifier, Detector and output

By
D. R. Bowman, B.Sc.
Royal Air Force

THREE stages of i.f. amplification (at 10·7Mc/s) are employed, and these are followed by a ratio detector.

It is worth mentioning at this point that although some hi fi people would regard this with some surprise, the decision to use a ratio detector is backed by sound principles. Eyebrows may be lowered. The ratio detector is capable of just as linear a response as the Foster-Seeley or the earlier Rond-Travis discriminators, and although the Foster-Seeley has been the "standard" for valve users for a good many years, nowadays more and more designers are using the ratio detector.

For transistor circuits the Foster-Seeley has notable disadvantages unless a relatively low i.f. is used, and the bandwidth needed has to be obtained by a much more critical i.f. amplifier set-up.

The theoretical man will appreciate that the mathematics of either type of discriminator show just the same opportunities for distortion, and that this can be minimised by using an i.f. amplifier whose response curve is "gaussian"—that is, bell-shaped—giving the most linear phase change through resonance point. Any reasonably advanced text book on electric circuit analysis may be consulted on this point, for example M.I.T. Radiation Laboratory Series Vol. 18—Vacuum Tube Amplifier (Valley & Wallman; McGraw-Hill Book Co.).

What is very important is to see that the i.f. amplifier and detector overall response is a smooth curve, rising steadily (though rapidly) to a peak at resonance and dropping off thereafter in an equally steady and rapid way. Any bumps or spikes on this curve are reflected in irregularities of phase-change, and consequent kinks in the phase characteristic. Fig. 13 illustrates a good and a bad type of response curve, with the appropriate phase characteristic.

To ensure that the i.f. amplifier has the proper response fixed neutralisation has been abandoned, and variable neutralising capacitors are used instead, TC3, 4, and 5. These have to be adjusted, when the i.f. amplifier has been built, to get the proper response curve.

CRITICAL WINDINGS

The construction of the i.f. amplifier transformers is also somewhat critical, especially as regards the gauge of wire used and the spacing between primary and secondary. (Refer to data and Fig. 8 in last month's article.) Coupling has been arranged to be a little less than "critical", except in the detector stage where joint critical coupling is employed.

If any difficulty exists in deciding the spacing, one should err on the generous side, rather than bring the windings even fractionally too close. Also the wire must be wound close, that is, with the adjacent turns touching. Any systematic gap will increase the winding length unacceptably. This is not usually a bother when coils are wound by hand, but if a winder is used the coils should be carefully inspected after construction.

Correct spacing is best obtained by cutting a strip of drawing paper the exact width required, and with it winding a spacer centrally on the former. The windings can then be started from the centre, hard up against the spacer; the latter may be removed later, when the fixing cement is hard and dry, but there is no real need to do this.

With regard to the detector transformer T7, particular care is necessary here, since a number of associated components have to be fitted inside the screening can in addition to the actual transformer assembly. Provided the smallest size of components is used, the "long" can specified will accommodate all items shown inside the dotted line which represents the can in Fig. 11. Details of the assembly of these components on the coil former are given in Fig. 12.

THE ETCHED CIRCUIT BOARD

The etched circuit is set out on a piece of copper clad laminate measuring 2¾in by 8in, as shown in Fig. 10.

The conductors are relatively few, and may be drawn direct on to the laminate surface with an acid resist. Thinner cellulose paint may be used for this quite successfully, but the vapour is dangerous to inhale and the process should be done in the open—or at the least, in an extremely well-ventilated room.

The best resist the writer has discovered is a proprietary french polish type of fluid known and marketed as "Glitseal", which is obtainable from "do-it-yourself" shops. This has to be diluted with about one-third of its volume of methylated spirit, as it is too thick for accurate small work, and for visibility it is dyed with a few crystals of crystal violet, obtainable from any dispensing chemist.

The conductors may be drawn with this mixture, using a ruling pen preferably as a small brush cannot readily be set against a straight edge. It should be noted that the conductors N, P, Q, and R are the earthing strips for the i.f. transformer cans, and conductor S is the earth point for the coaxial socket output to the i.f. strip. The conductor A is the common "earth" connection, and is best made quite wide as several component leads have to be soldered to it.

When the "conductors" are dry and hard, a careful check should be made to see that all is well. Then the etching process may be carried out, using 30 per cent ferric chloride solution in the usual way—see last month's article.

The theoretical circuit of the i.f. amplifier, detector, and pre-amplifier is given in Fig. 11, and during the wiring-up procedure this diagram should be consulted frequently to ensure that no errors occur. When wiring is complete the circuit board should be given a coating of varnish—the "Glitseal" is excellent for this purpose—to protect the copper laminate against corrosion.

ALIGNMENT OF THE I.F. STAGES

To set up the i.f. amplifier the following method should be followed. This will enable a stable and well-tuned amplifier to be achieved, which is then trimmed for the correct response curve.

A multimeter is needed, and a signal generator capable of supplying a signal of 10·7Mc/s, amplitude modulated or unmodulated at will. The leads from the multimeter should be decoupled at the ends by means of 5 kilohm resistors, and these soldered lightly to tags 3 and 11 (across the stabilising capacitor of the ratio detector). The leads must be arranged to lie well away from the i.f. stages.

Set the multimeter to the 50μA or 100μA range, and the signal generator to high output.

Set the neutralising capacitors TC3, 4, and 5 to minimum. Disconnect the two 100Ω decoupling resistors R17, R21 from the B− line; this leaves only the ratio detector driver transistor and the pre-amplifier transistor in operation. The battery supply is now connected.

Most likely at this stage the microammeter will show a reading, indicating the stage is oscillating. Rotate the adjustment of TC5. Two positions will be found at which the stage breaks into oscillation, with a space between when no oscillations occur. Obtain the centre setting. Switch on the signal generator and bring the "live" lead near the base of TR6. Rotate both cores of T7 until maximum deflection of the meter is obtained, reducing the signal generator output if necessary. It may well happen that as the transformer is brought into line TC5 will require re-adjustment, but there is no difficulty at all in tuning up this stage and neutralising it.

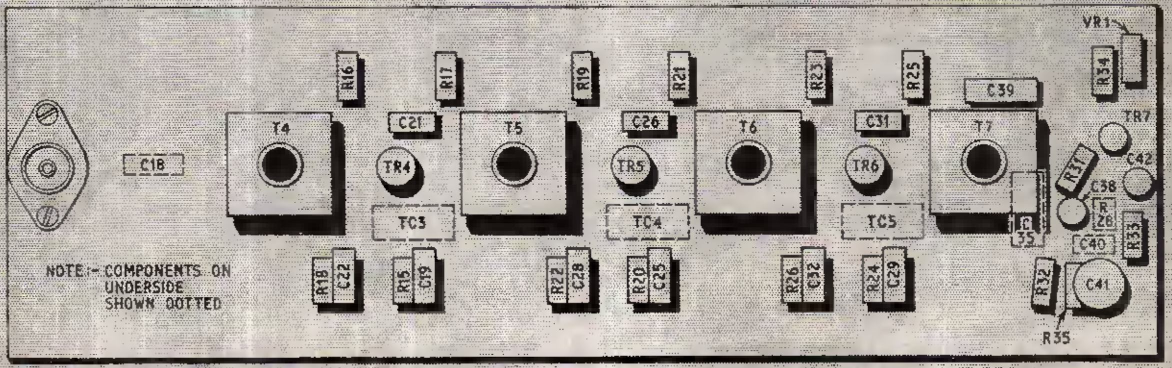
Next tune the secondary of T5 until maximum meter deflection is reached, once again adjusting TC5 as necessary to recover stability. No contact should be necessary between the signal generator lead and the base of TR6, but if the signal generator output is small the lead may be connected via a small capacitor to the primary of T6 at the collector terminal of TR5.

Next transfer the signal generator lead to the base of TR5, again without physical contact, and re-tune the transformer T6. As the transistor for this stage is not working yet, a small reading only will be obtained unless the signal generator output is increased. Connect up the decoupling resistor of this stage (R21), to bring the stage into operation. Again, oscillation will probably result, and in the absence of an input signal a meter reading will be obtained. Adjust TC4 to stabilise the circuit, and tune the secondary of T5.

Couple in R17, and repeat the above adjustments with T4, T5, and TC3. At this stage it may well be found that *very small* adjustments of TC4 and TC5 are required to retain overall stability. These will amount only to a fraction of a turn—10 degrees or so of adjustment is usually enough.

Now that the i.f. amplifier is stable and roughly tuned the signal generator output lead should be plugged into the coaxial socket SK2, and the output reduced to a few microamps r.f. Re-tune the entire receiver for maximum output at the meter. It should

Fig. 9. A top view of the i.f. printed board showing component layout



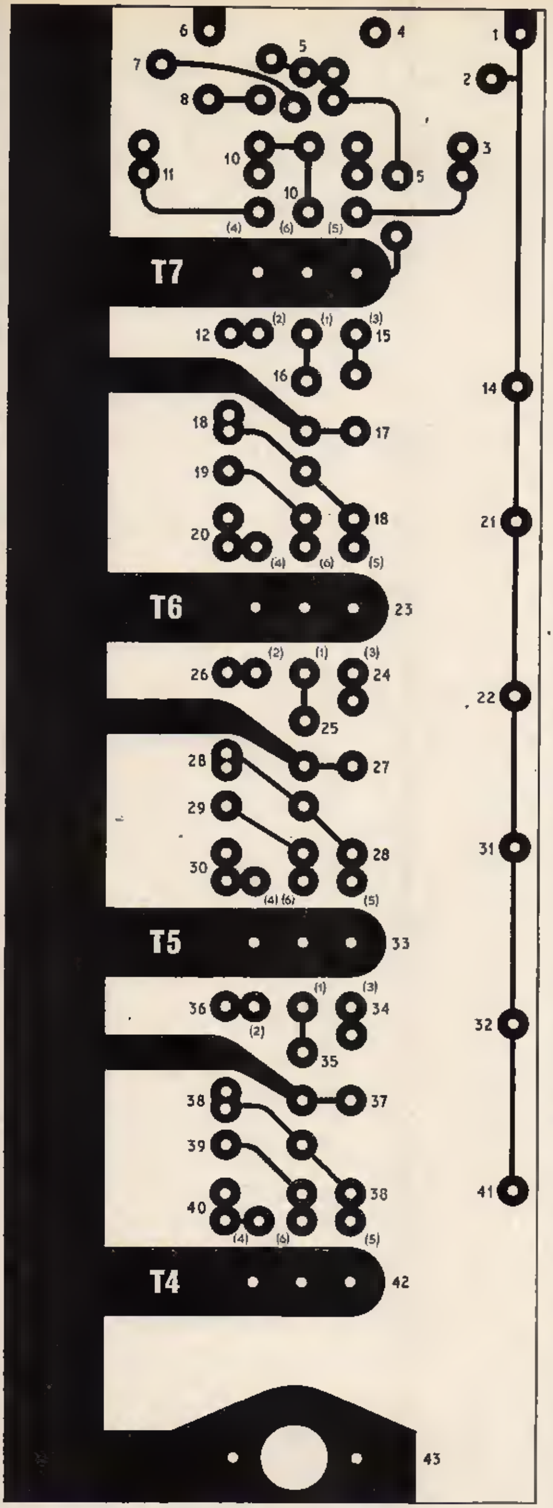


Fig. 10. Printed board. The small numerals refer to similarly numbered points on the circuit. The small numbers in brackets are the pin numbers of the coils. See Fig. 11. The common earthing strip on the left-hand side is referred to as "A" in the text

be found that the stages tune quite independently. If not, neutralisation is not exact. *Very slight* adjustments of all three neutralising capacitors are now needed, with re-tuning of the transformers as necessary, until the transformers tune independently, and a change in the setting of one core does not affect the timing of the next stage.

VISUAL ALIGNMENT

If a wobbulator (i.e. frequency modulated oscillator) and an oscilloscope are available it is possible to align for the best response curve.

For this, deviation is set to the maximum; and the stabilising capacitor C38 temporarily disconnected from points 3 and 11; and the oscilloscope connected to these points. If necessary, one of these points may be earthed temporarily. Extremely slight adjustment of transformer tuning and of the neutralising capacitors will permit a smoothly-rounded curve to be obtained.

THE DETECTOR

The next step is to adjust the ratio detector. Reattach the stabilising capacitor C38 between points 3 and 11, and connect a pair of headphones (or audio amplifier) to detect the modulated output. Connect the signal generator output to the coaxial input socket SK2. Switch on the modulation in the signal generator. Maximum sound output will not be obtained, but there should be some. Rotate the core of the secondary of the discriminator transformer T7 until *zero output* is obtained. This will be quite sharp.

Next, if a wobbulator is available set to 25kc/s deviation and connect its r.f. output to the input socket and the oscilloscope between points 5 and earth. While listening to the output, tune the wobbulator gently so that its output frequency slowly reaches the intermediate frequency to which the i.f. amplifier is tuned.

As the wobbulator comes into tune, the harsh-sounding third harmonic should disappear completely, leaving a pure tone. Meanwhile the trace should show a straight line inclined to the X axis. Increasing now the deviation to a large extent will reveal all or part of the phase response curve. If all has gone well, the trace should closely resemble Fig. 9a. If not, very slight further adjustments may be made until the perfect characteristic is approached.

If exceptionally high fidelity is not the aim, the wobbulator test may be omitted, the final check being to tune the signal generator gently through the i.f. with the meter connected across the stabilising capacitor C38 as before, and the amplitude modulation switched on. The output should be monitored aurally.

As resonance is approached the meter reading should rise steadily, in the same way as the amplitude characteristic of Fig. 9a, as the sound output increases. As resonance is approached the sound should die away to zero as the meter approaches maximum. A check should be made that the peaks of the most intense sound are equally spaced about the zero point. Also, by connecting a meter between point 10 or 13 and chassis, check that a zero reading is obtained at the zero sound output point and that equal positive and negative readings are obtained at equal frequencies off resonance.

The conditions necessary for this are that the ratio detector transformer should be absolutely symmetrical, and that it should be matched each side. The 470 ohm and 6·8 kilohm load resistors R29, R30, R31, and R32 should therefore be matched as exactly as possible from stock; for "hi fi" results, match should be to 1 per cent or better. In such a case a matched pair of OA79 diodes is useful, and if they differ (as supplied) by more than 10 per cent it may be advisable to increase the 470 ohm resistors to 680 ohms—also carefully matched.

The two 500pF capacitors C36 and C37 should also be close in value, but this is less important. It is better to get a close match between the load resistors than to be very precise about the actual numerical value.

OUTPUT ARRANGEMENTS

The pre-amplifier stage TR7 is arranged for pre-set output. If this receiver is to be used in association with a sensitive power amplifier (such as the 5W Integrated Amplifier currently appearing in our pages) it may be feasible to dispense with the gain of this stage and instead employ the transistor TR7 as an emitter-follower. This is recommended for the highest quality reproduction.

To effect this change, remove VR1 and connect the collector of TR7 direct to the B− rail. Change the value of R35 to 1·8 kilohm, and remove C41. Output at a few ohms impedance is then taken from the emitter of TR7.

If a coupling capacitor is to be used between this and the next audio stage, a 500μF capacitor should be used. It will be preferable however to use direct coupling into the base of the next stage if d.c. conditions can be achieved correctly.

I.F. INTERFERENCE

The author has found that in certain locations interference can be obtained from transmissions on the intermediate frequency of 10·7Mc/s if any r.f. signal finds its way into the i.f. amplifier. Provided the interfering signal is not so strong as to cause cross-modulation with the desired signal, direct r.f. pick-up can be avoided by good screening and by adequate selectivity in the r.f. stages.

However, in this receiver unit construction is employed, and connecting cables may cause a certain amount of pick-up at i.f.; added to which is the possibility of direct pick-up on the circuit wiring of the i.f. amplifier, unless an earthed screening box for the whole unit is made. Usually, however, it is possible to find a quiet spot within a few hundred kc/s of the nominal i.f., and this is the recommended procedure if interference is experienced.

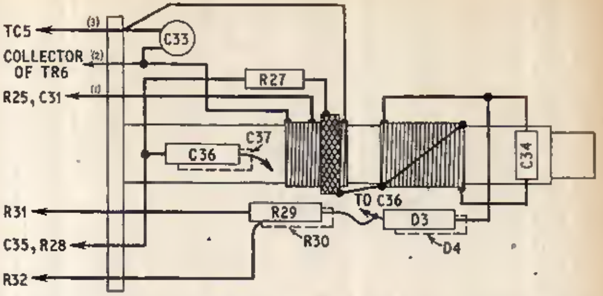


Fig. 12. Wiring of ratio detector circuit. D4, R30, C37 are behind D3, R29, C36, and are similarly wired. When assembled all components should be wrapped in a layer of thin polythene to ensure insulation from the can. For coil connections see Fig. 8 in last month's article

ALIGNMENT OF THE R.F. UNIT

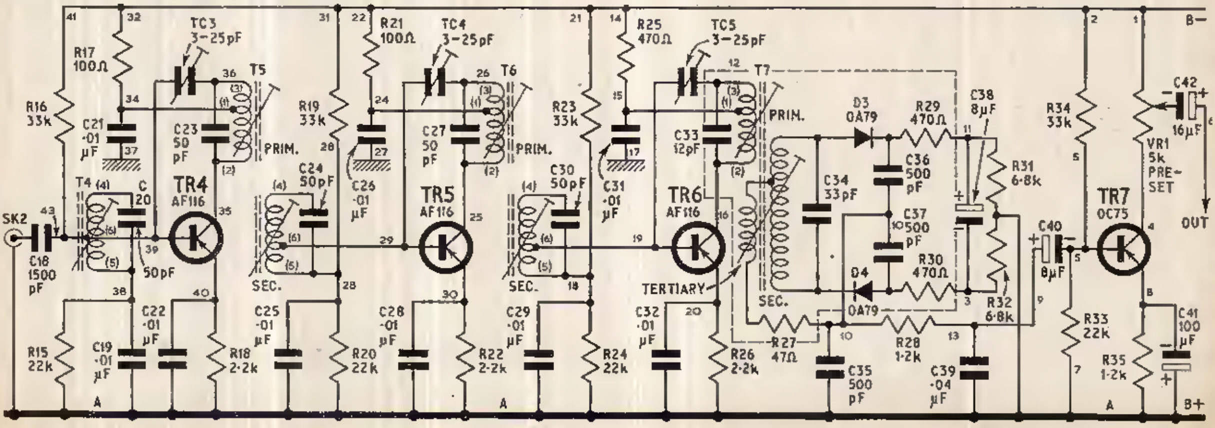
Having roughly ascertained that the oscillator is working in the correct frequency band—in the way previously mentioned—all that remains is to effect a careful alignment using a meter. Either phones or a small loudspeaker may be connected between C42 and B+, or an a.f. amplifier may be attached.

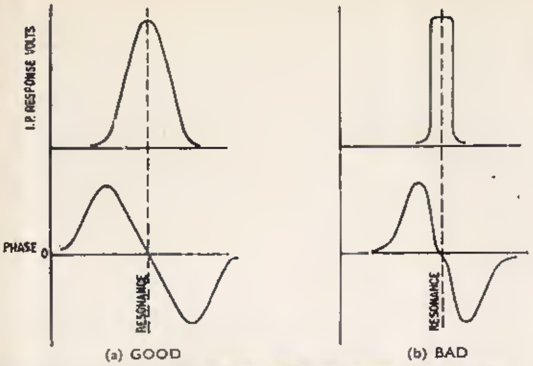
A test oscillator or signal generator is required capable of giving a modulated output (preferably f.m.) over the range 85–100Mc/s. This is set to 87·5Mc/s, and connected to the aerial socket of the receiver; moderate output will be required, say 10mV. The volume control should be adjusted so that the receiver does not emit too much noise. Set the ganged capacitors to maximum (full interleaved) and rotate the core of the oscillator inductor (L2) until a signal is heard. If too loud reduce the signal generator output. Tune the oscillator for peak signal by means of the core. If the signal can be heard at two settings of the core, select the position corresponding to the smaller value of inductance.

Set the signal generator to 100Mc/s and the ganged capacitor to minimum. Adjust the oscillator trimming capacitance until maximum signal is heard. Next set the gang to the half-way position, and tune the signal generator for maximum output in the receiver. Rotate the core of the aerial coupling inductor and of the r.f. interstage transformer for maximum volume.

During the above procedure it will be found that when exact tuning with the signal generator is achieved the modulation disappears, unless the signal generator

Fig. 11. Circuit diagram of the i.f. unit





(a) GOOD (b) BAD

Fig. 13. The i.f. amplifier and detector response curve showing good (a) and bad (b) characteristics

is frequency-modulated. However, a slight mistuning one way or the other will bring in the modulation sufficiently well for the output to be estimated. The following procedure, however, should be carried out with an f.m. signal, or failing this with an extremely small input. The latter can be achieved by attaching the aerial to the receiver—using the signal generator as a low-power transmitter. The signals when received should be barely above the noise level, so that the limiting effect of the ratio detector is at its minimum. Alternatively, the broadcast stations themselves may be used for alignment, but this method is not as accurate and may take more time.

The procedure given in the above paragraphs should now be repeated, except that the aerial π-coupling should not be re-adjusted. Further repetition will give more accurate alignment, but it is seldom necessary to perform the operation more than three times in all.

If a meter is used for the alignment, it should be connected across the capacitor C38. The voltage developed, with an aerial input of 10μV, will be about 1V, but the response is highly non-linear and when the receiver is aligned the BBC transmissions may not give much more than this. Provided the signal generator output is kept as low as will give a reasonable meter deflection there should be no difficulty in achieving correct alignment. ★

COMPONENTS . . .

*Items marked * are not required if an emitter-follower output stage is employed.*

Resistors

R15	15kΩ	R22	2·2kΩ	R29	470Ω
R16	22kΩ	R23	22kΩ	R30	470Ω
R17	100Ω	R24	15kΩ	R31	6·8kΩ
R18	2·2kΩ	R25	470Ω	R32	6·8kΩ
R19	22kΩ	R26	2·2kΩ	R33	22kΩ
R20	15kΩ	R27	47Ω	R34	33kΩ
R21	100Ω	R28	1·2kΩ	*R35	1·2kΩ
	All ¼W carbon			R35	1·8kΩ

*VR1 5kΩ preset carbon potentiometer

Capacitors

C18	1,500pF	C30	50pF
C19	0·01μF paper	C31	0·01μF paper
C20	50pF	C32	0·01μF paper
C21	0·01μF paper	C33	12pF
C22	0·01μF paper	C34	33pF
C23	50pF	C35	500pF
C24	50pF	C36	500pF
C25	0·01μF paper	C37	500pF
C26	0·01μF paper	C38	8μF elect. 15V
C27	50pF	C39	0·04μF paper
C28	0·01μF paper	C40	8μF elect. 15V
C29	0·01μF paper	*C41	100μF elect. 15V

All silver mica or high quality ceramic, unless otherwise indicated

TC3, TC4, TC5 3–25pF

Transformers

T4, T5, T6 I.F. transformers—see text
T7 Detector transformer—see text

Transistors

TR4	AF116	TR6	AF116
TR5	AF116	TR7	OC75

Diodes

D3	OA79	D4	OA79

Miscellaneous

SK2 coaxial socket

OFFICE WORK MADE EASY . . .

ELECTRONICS is playing an important part in automation of office methods and it was evident from the Business Efficiency Exhibition, held at Olympia on 5–14 October, that the modern business establishment is finding new ways of speeding up office work and reducing the risk of error.

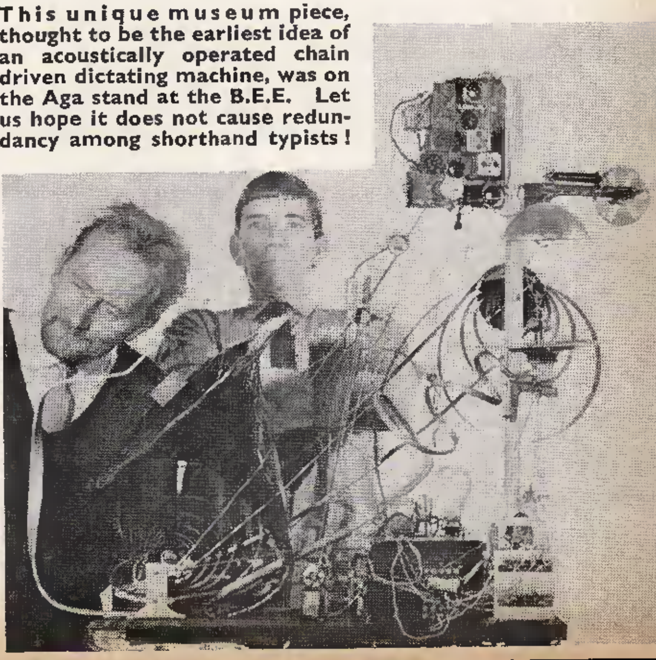
Among new developments there was the new electronic calculator, on show for the first time by Friden, which displays four rows of numbers and answers, including the decimal point and function signs, on a small c.r.t.

The decimal point can be positioned to give 0, 2, 5, 7, or 11 decimal place working, and any number of calculations can be made instantaneously by operating a simple 10-key keyboard.

The emphasis on quick and simple operation of dictating machines has been further enhanced by automatic tape threading and coupling to the take-up spool by the operation of a simple lever. The operator of one particular model, made by Philips, need not and indeed cannot touch the tape himself once the cassette is on the machine.

Another new dictating machine, developed by Grundig, uses foil, instead of the more conventional oxide coated plastic tape.

This unique museum piece, thought to be the earliest idea of an acoustically operated chain driven dictating machine, was on the Aga stand at the B.E.E. Let us hope it does not cause redundancy among shorthand typists!

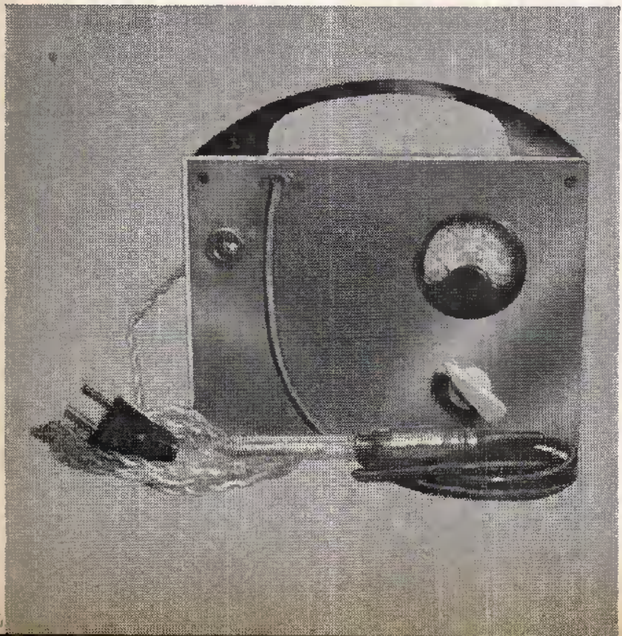


RADIOACTIVITY experiments

Some Practical Applications of the Geiger-Muller ratemeter are described by

J. F. ROWLES

These simple experiments can be performed quite safely by any amateur interested in investigating the nature of radioactivity.



Last month instructions were given for the construction of a simple Geiger-Muller ratemeter. In this article it is proposed to describe a series of basic experiments that will give the user of the ratemeter an introduction to the nature of radioactivity.

Before beginning, it would probably assist if a few basic facts concerning the atomic particles emitted in radioactivity were mentioned. There are many particles that are emitted or can be emitted by an atom under different conditions. Here we are only concerned with natural radioactivity and will only consider *alpha, beta* and *gamma* radiation.

ALPHA PARTICLES

Alpha particles have the following properties:

Cause fluorescence; blacken photographic emulsions; produce ionisation in gases. They are easily absorbed by matter; deflected by magnetic and electric fields; and are emitted with large velocities.

The alpha particle has been shown in fact to be a helium nucleus,

$_2\mathrm{He}^4$ *(a positively charged ion)*

BETA PARTICLES

Beta particles have the following properties:

Cause fluorescence, though not as great as alpha particles; blacken photographic emulsions; cause ionisation, but to a lesser extent than alphas. They have much greater penetration than alphas; are deflected by magnetic and electric fields; and have extremely high velocities.

Beta particles, in fact, consist of electrons moving with extremely high velocities. *They carry a negative charge.*

GAMMA RAYS

Gamma rays were found to have the same properties as X-rays:

Unaffected by electric or magnetic fields; travel with the velocity of light; cause fluorescence; blacken photographic plates; cause a small amount of ionisation. They very easily penetrate matter; can be diffracted; cause interference; and can eject electrons from material.

The gamma rays are electromagnetic waves of shorter wavelength than X-rays. The wavelength of the rays emitted depends on the emitting material.

RANDOMNESS IN RADIOACTIVE DECAY

The randomness of radioactive decay is very easily demonstrated using the ratemeter and a radioactive source such as the luminous face of a clock or watch.

Set up the ratemeter with the luminous dial near to the G-M tube. It will be noted that the ratemeter needle does not give a constant reading but fluctuates to a certain extent, showing that the atoms of the source are not emitting at a constant rate, their emission being quite random.

INVERSE SQUARE LAW OF GAMMA RADIATION

Like light radiation, gamma radiation obeys the inverse square law. This states that the intensity of radiation observed is inversely proportional to the square of the distance from the source.

To verify this is simple, all that is needed is a gamma source and the ratemeter. A suitable gamma source

IMPORTANT NOTICE

R1 and R2 should be 2·7MΩ and *not* 2·7kΩ as given in last month's article—pages 30 and 32.

is radium shielded by thin aluminium sheet to stop the unwanted beta and alpha rays. A luminous clock or watch face can be used, but it is better to have a more concentrated source such as some of the luminous paint used by watchmakers. This paint can be purchased from a wholesaler in such goods, and is packaged in a small test tube (of the type known as semi-micro test tubes).

The method of testing the inverse square law is to take the count rate at varying distances from the source and to plot a graph of 1/distance squared against the count rate. (See Fig. 1.)

Alternatively, a logarithmic graph can be plotted of log distance against log count rate. Here the relationship is verified more exactly as the assumption of the inverse square law applying is not assumed but the power to which the distance has to be raised to satisfy the equation is arrived at from the graph. (See Fig. 2.)

A typical set of results will now be treated to give the graphs mentioned:

Distance	$\frac{1}{(Distance)^2}$	*Count Rate*	*Log Distance*	*Log Count Rate*
2	0·25	100	0·3	2·0
3	0·1	45	0·48	1·65
4	0·063	25	0·6	1·4
5	0·04	15	0·7	1·178
6	0·03	10	0·78	1·0
7	0·02	8	0·85	0·9
8	0·0156	6	0·9	0·78

Mathematically, the inverse square law is expressed as

$$R = \frac{k}{d^2}$$

R = Count rate

d = distance

Taking logs,

$$\log R = -2 \log d + \log k$$

Thus the power to which d must be raised can be obtained from the log graph as above (data for these graphs were from actual records using the ratemeter described last month).

It can be seen that the power to which the distance had to be raised was not determined exactly as 2, but consideration of the errors involved in the experiment (mainly in taking the reading from the ratemeter) shows the result to be within the range of experimental error.

This may seem to be a high error, but the ratemeter was not designed to give extremely high accuracy, and it must be remembered that the needle of the meter flickers to some extent all the time, presenting a difficulty in determining exactly what the reading should be. Each experimenter will have his own idea of where the arithmetic mean of the flickerings lie.

HALF LIFE AND ITS DETERMINATION

In radioactivity the decay of a substance is exponential, it never being completely annihilated, hence to talk of its total active period is impossible; so the time taken for *half* the specimen to decay away by radioactivity is taken as a measure of its term of existence, this being called the *half life.*

Treating this mathematically, suppose a given sample of radioactive compound contains N radioactive atoms at some time t, and the probability that each of these will decay in any one second is represented by a constant a (the decay constant).

Then the average number of atoms dN that decay in a time dt is given by,

$$dN = -aNdt$$

Integrating this over a time $t = 0$ to $t = t$

$$\int_{N_0}^{N} \frac{dN}{N} = a \int_{t=0}^{t=t} dt$$

hence,

$$N = N_0 e^{-at}$$

Where No is the number of atoms present at time $t = 0$. The ratio N to N_0 is the fraction of radioactive atoms remaining unchanged after a time t.

The decay constant, a, is the fraction of the total number of atoms that decay in unit time (provided unit time is small enough). The units of the decay constant are reciprocal time, it usually being expressed as reciprocal seconds. Its value is constant and specific for a given nucleus.

Practically, this decay constant is not used, but half life, mentioned above.

At a time $t = \frac{1}{2}t_0$, the number of atoms remaining, N, equals $\frac{1}{2}N_0$. Substituting in the integral formula,

$$\tfrac{1}{2} = c^{-a\frac{1}{2}t}$$

or

$$\log_e\tfrac{1}{2} = -at_{\frac{1}{2}}$$

($t_{\frac{1}{2}}$ is the half life)

then,

$$t_{\frac{1}{2}} = \frac{\log_e 2}{a}$$

Fig. 2 (right). A logarithmic graph of log distance against log count rate

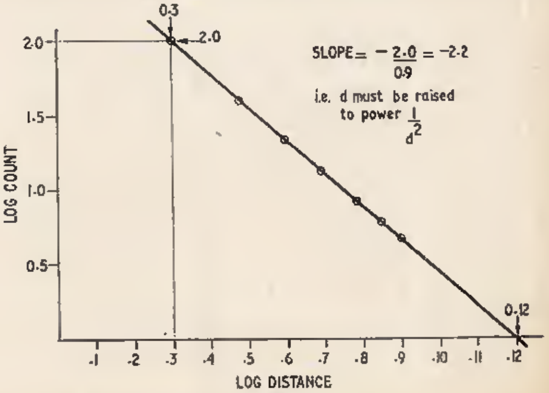
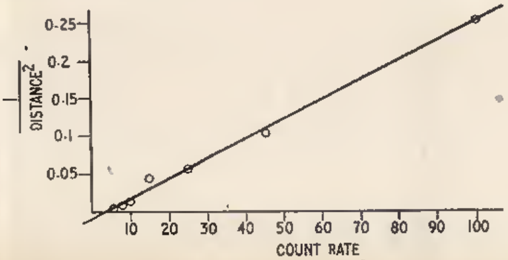


Fig. 1 (below). This graph shows 1/distance squared plotted against count rate



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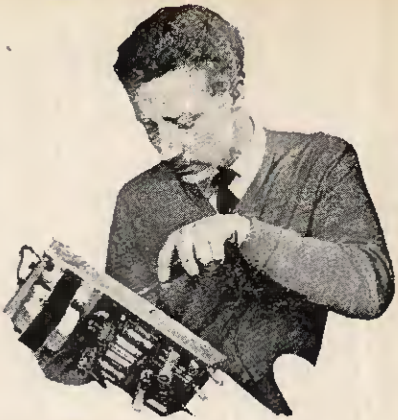

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PE 12.64.

The actual rate of decay of a specimen is equivalent to the rate of emission of photons or particles, since each atom gives rise to a particle and/or a photon of radiation. This rate of emission is therefore the same as the absolute rate of decay, represented by,

$$\frac{-dN}{dt}$$

It is very difficult, however, to detect and record every single particle emitted from a radioactive mass, although it is possible to measure a constant fraction of that decay. This distinguishes between the count rate registered on the G-M ratemeter and the true rate of decay. The relationship between the two can be given as follows,

$$C = K\left(\frac{-dN}{dt}\right)$$

Where K represents the overall efficiency of the detection.

The numerical value C may replace the true rate of decay in the integrated decay equation.

$$C = C_0 e^{-at}$$

Hence,

$$\log_{10} = -0{\cdot}4343at + \log_{10} C_0$$

The logarithm of the measured count rate, C, plotted against the time, yields a straight line graph of slope 0·4343a, from which a and hence $t_{\frac{1}{2}}$ can be found. In practice it is easier to plot count rate on semi-logarithmic graph paper against the time, and read off $t_{\frac{1}{2}}$ directly. (See Fig. 3.)

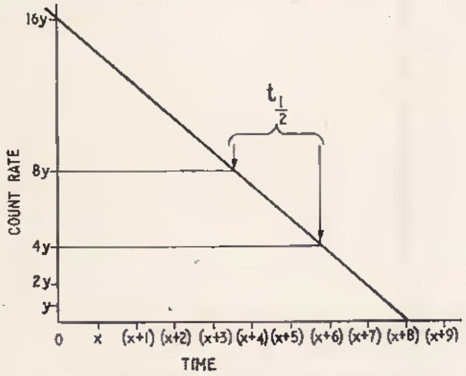


Fig. 3. Count rate plotted against time on a semi-logarithmic graph

It can be seen from the above description and the graph, that to obtain a value for the half life of a substance, a graph from which the slope can be easily determined or from which the half life is directly obtainable, is essential. This means that this method can only be employed for the determination of the half lives of substances in which that period is practicably short (say, up to one year). Thus the substances that the amateur normally deals with (uranium and radium mainly) whose half lives are extremely long (1,000 years at least) cannot easily be treated in this manner to obtain values for the half life period.

For the determination of the long half lives a special technique is employed. Here the rate of decay and the number of atoms present in the specimen are determined separately, these together with knowledge of the Avogadro number for the specimen (the number of molecules in one gram molecule of a substance). The value of the Avogadro number is $6{\cdot}02 \times 10^{23}$ molecules per mole. In the actual determination of the half life the quantities required are the decay rate, the weight of substance under examination (accurately in grams), the gram molecular weight (from tables), and the Avogadro number.

It must be remembered that the count rate recorded by the ratemeter is not the decay rate but a fraction of it, and before any determinations of half lives can be undertaken this relationship must be established.

A SIMPLE PIECE OF APPARATUS

It will be of great use if the following simple piece of apparatus is constructed and used when determining half lives. It consists of a short length of wood with mounts for the G-M tube and the source holder. No dimensions have been given as these depend on the size of G-M tube available. The tube is mounted through holes drilled in blocks of wood which are mounted in the positions shown in Fig. 4.

Once the relationship between count rate and decay rate has been determined for the apparatus it can easily be used for future determinations of half lives. The relationship can be determined in two ways: by consideration of the geometry of the arrangement and by experiment, assuming the half life of a substance.

Considering the geometry of the system, the source can be considered as a point source as the quantities used by the amateur are small. Referring to Fig. 5, the following measurements must be made:

1. The distance from the centre of the source to the G-M tube—"d".
2. The width of the G-M tube—"a".

Hence from the geometry of the figure,

$$\tan A = \frac{a}{d}$$

hence A can be found in degrees.

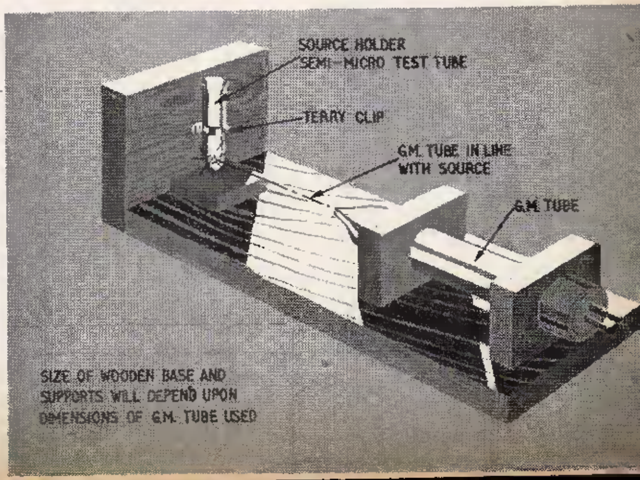
The constant relating count rate to decay rate is then 360/A, assuming that the specimen radiates equally in all directions.

Having determined the constant for the apparatus it can now be used to find half lives. The method is as follows.

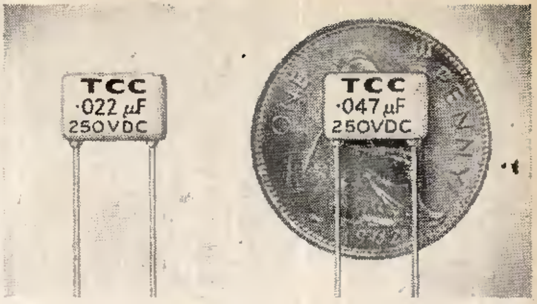
The first consideration is the fraction of radioactive material in the specimen under examination. Consider a radioactive element, M, existing in a compound, MX, which is under examination. The fraction of M present is then the ratio of M to M + X. A practical examination will now be given. In the compound radium chloride, the fraction of radium present is found as follows

$$\text{Molecular weight of Ra Cl}_2 = 226 + (35{\cdot}5)2$$
$$= 297$$

Fig. 4. Simple apparatus for half life experiments



MINIATURE METALLIZED POLYESTER CAPACITORS



These small moulded metallized polyester capacitors are ideally suited to the applications to printed wiring panels and transistorised circuits. The use of the new dielectric material and unique construction combine the advantages of small physical size and superior electrical characteristics which meet the requirements of H.5 DEF. 5011 Specification.

CONSTRUCTION

The windings are virtually non-inductive and the wire terminations are soldered direct to the metal electrodes eliminating contact resistance and ensuring the minimum possible inductance.

Cap. Tolerance: ±20%

Voltage Rating:
Peak ripple voltage and D.C. voltage must not exceed rated D.C. voltage.

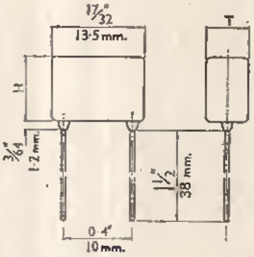
Power Factor:
≤0.01 at 1 Kc/s. at + 20°C.

Temperature Rating:
Suitable for working at + 85°C. without derating.

Insulation Resistance:
10,000 megohms or 2,000 ohm Farad whichever is less.

Terminations:
22 SWG solder coated parallel wires for vertical mounting.

Finish:
Insulated—special non-cracking heat resisting thermosetting compound providing good insulation and good protection against the ingress of moisture.



Cap. µF	Dimensions		T.C.C. Type No.
	H	T	
250 V. D.C. at 85°C working			
0.01	11/32in. 9 mm	7/32in. 5.5 mm	PMX1
0.015	11/32in. 9 mm	7/32in. 5.5 mm	PMX7
0.022	11/32in. 9 mm	7/32in. 5.5 mm	PMX2
0.033	11/32in. 9 mm	7/32in. 5.5 mm	PMX5
0.047	11/32in. 9 mm	7/32in. 5.5 mm	PMX3
0.068	7/16in. 11 mm	9/32in. 7.2 mm	PMX8
0.1	7/16in. 11 mm	9/32in. 7.2 mm	PMX4
400 V. D.C. at 85°C working			
0.01	11/32in. 9 mm	7/32in. 5.5 mm	PMX41
0.022	11/32in. 9 mm	7/32in. 5.5 mm	PMX42
0.033	7/16in. 11 mm	9/32in. 7.2 mm	PMX45
0.047	7/16in. 11 mm	9/32in. 7.2 mm	PMX43

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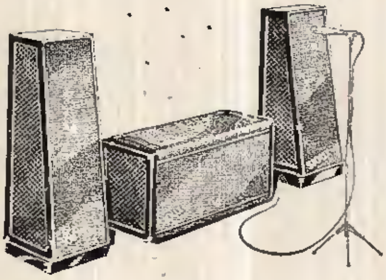

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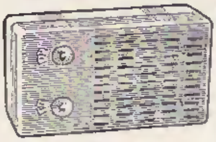
MAINS POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6 v.—9 to 12 volts for up to 500 mA. (class B working). Takes the place of any of the following batteries. PP1-PP3-PP4-PP6-PP7-PP9 and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor 5,000 and 500 mfd. condensers, zener diode and instructions. Real snip at only 14/6, plus 2/6 post.

OUR BARGAIN OF THE YEAR

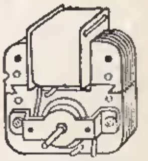


Complete kit of parts to build this 6-transistor 2 wave superhet receiver at only **39/6** plus 2/6 post and ins.

"CORONET" Mk. III

It fully covers the medium-wave band and that part of the long-wave band to bring in B.B.C. Light. The circuit includes a highly efficient slab aerial and 2½" P.M. speaker. Overall size approximately 4½ × 2¾ × 1½in. Supplied complete with carrying case.

MOTOR BARGAIN



Silent running mains motor by very famous maker. Ideal for gramophone, tape recorder, fan, etc. etc. 200-250 volts. A.C. shaded pole start. Size approximately 2¼ × 2¼ × 1⅛in., 2,750 r.p.m. Spindle diameter 5/32in. Spindle length ⅞in. Brand new guarantee. Price **12/6** plus 1/- post.

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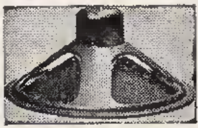
POLES	2 WAY	3 WAY	4 WAY	6 WAY	8 WAY	10 WAY	11 WAY	12 WAY
1	2/8	2/10	3/1	3/6	4/-	4/6	4/6	4/8
2	3/3	3/8	4/1	4/11	6/-	7/-	7/-	7/6
3	3/11	4/6	5/2		8/-	9/6	9/6	10/3
4	4/6	5/4	6/2	7/10	10/-	12/-	12/-	13/-
6	5/9	7/-	8/3	10/9	15/-	17/-	17/-	18/6
8	8/-	8/8	10/4	13/8	18/-	22/-	22/-	25/-
10	10/-	10/6	12/5	16/9	22/6	27/-	27/-	30/-
12	12/-	12/6	14/6	19/8	27/6	32/-	32/-	36/-
14	14/-	14/6	17/-	22/6				
16	16/-	16/6	19/6	25/6				

5 WAY 1 pole 3/6 2 pole 4/9 **24 WAY** 1 pole 15/- 2 pole 22/6

Speaker Bargain



12in. High fidelity loudspeaker. High flux permanent magnet type with standard 3 ohm speech coil. Will handle up to 12 watts. Brand new, by famous maker. Price **27/6**, plus 3/6 post and insurance.

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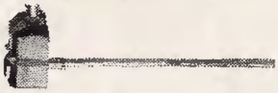


Suitable for Industrial or domestic purposes such as controlling furnace oven, immersion heater, etc. Can also be used as a flamestat or fire alarm. Made by Sunvic these are approximately 17in. long and adjustable over a range 0 to 550°F. The contacts are rated at 15 amps. 230 volts, and the adjustment spindle, which comes to the top, can be fitted with a flexible drive for remote control or just a pointer knob for local control. Listed at £3 or £4 each, these are offered at only **8/6**, plus 2/6 postage and insurance.

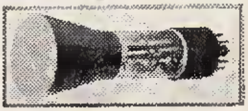
Timer Kit

Special offer of all components except metal box to make mains operated interval timer for photography, etc., **12/6** plus 2/6 post.

Waterproof Heater Wire

16 yd. length. 70 watts. Self regulating temperature control, **10/-** post free.

Building a Scope?



3in. oscilloscope tube. American made type No. 3FP7, base 6.3 v. 6 amp. heater electrostatic deflection, brand new and guaranteed, with circuit diagram of scope, **15/-** each plus 2/6 post and insurance.

Ice-Stat

This is a small thermostat which cuts on and off at round freezing point. Has many uses, one of which could be an ice warning device to be fitted under your motor car. Price **7/6**. Post 1/-.

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Suitable to control elements, heaters, soldering irons and boiling rings up to 2,500 watts. Complete adjustable, normal price 55/- each, special snip price **12/6**, plus 1/6 postage and insurance.

Siemens High Speed Relay

Twin 250 ohm coils adjustable tension change over contacts—platinum points **7/6**. Post 1/-.

BARGAINS

Air Spaced Trimmers, good length ¼in. spindle 0-50pf. but easily converted down to 0-5 pf. 2/6 ea., post 1/-. Ditto but 2 gang for F.M. Tuners etc., **4/6** ea. Post 1/-.

High Voltage Condensers. 2 mfd. 1.2 kv. **4/6**, 4 mfd. 1.5 kv. **6/6**, 0.5 mfd. 4 kv. **6/6**, .01 mfd. 5 kv. **3/6**.

Trimmer Assortment. 3 doz. various sizes and types including doubles and ceramic air spaced. Retail list value over £4, all new and unused **10/-** for 36. Post 2/-.

Motor Generator, 6 v. input gives 12 v. output, suitable to run 12 v. car battery radio off 6 v. battery **17/6**, post and insurance 3/6.

Midget 3in. P.M. Loudspeaker 3 ohm, **12/6**, 8 ohm, **13/6**. **Midget** 208 pF+176 pF two-gang Tuning Condenser with trimmers for transistor set. **Price 9/-.**

Post Office Type Key Switch. 3 position 10 change over contacts **7/6**, post 1/-.

Rectifier Valves. 4 pin 4 v. 120 ma. full waves replace MU12 etc. **4/6**. P. & P. 1/-. **40/-** per doz. Post free.

Double Trimmers. Ideal for making pre-set station receiver 100 pf. plus 100 pf. **6/-** per doz. Post 1/-.

Mica Condenser. 100 pf. 200 pf. 300 pf. 500 pf. 1,000 pf. 3 doz. assorted list value £2. 36 for **5/-**. Post 2/-.

Litz Wire for coil winding. Normally over 40/- per lb. from makers, 1lb. reels **20/-** ea. Post and packing 2/-.

Hours Elapsed Meter. Fine American make unused but ex-equipment **35/-** ea., post 2/-. **12 v. 10 amp. Rectifier.** 8¾in. sq. plates **19/6**, post 2/-.

ELECTRONICS (CROYDON) LTD.
266 LONDON ROAD, WEST CROYDON, SURREY
Post orders to:
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Therefore the fraction of radium present is

$$\frac{226}{297} = 0{\cdot}761$$

A weighed specimen of the substance under examination is then taken and the weight of radioactive material present is found. The count rate observed from the specimen in the above apparatus is noted. The half life is then found as follows.

Let the count rate be C, the constant of the apparatus be 360/A, the weight of specimen taken W, the fraction of radioactive material present 1/f, and the Avogadro number L. Let the molecular weight of the specimen be M. Then,

$$\text{Weight of radioactive substance present} = \frac{W}{f}$$

$$\text{True decay rate} = \frac{360C}{A}$$

Number of atoms present in the radioactive specimen

$$= \frac{W \times L}{f \times M}$$

The decay constant "a" therefore equals,

$$a = \frac{360CfM}{AWL}$$

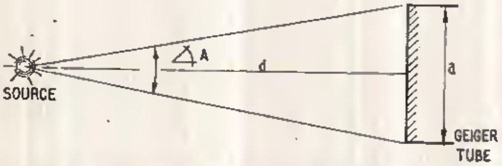

Fig. 5. Critical measurements in half life experiment set-up

A PRACTICAL EXAMPLE

A practical example from the author's own records will now be given.

Source to tube distance = 10cm
Weight of radium taken = 5 × 10^{-6} grammes
Diameter of G-M tube = 2cm
Count rate = 570/sec

$$\text{Angle of acceptance} = \tan^{-1}\frac{2}{10} = 11{\cdot}3^{\circ}$$

therefore,

$$\text{Decay rate} = \frac{570 \times 360}{11{\cdot}3}$$

$$= 18{,}150 \text{ counts/sec.}$$

Hence,

$$a = \frac{18{,}150 \times 226\,(\text{M.W. of radium})}{6{\cdot}02 \times 10^{23} \times 5 \times 10^{-6}}$$

(the weight of radium taken was 5 × 10^{-6} grammes)

Hence,

$$t_{\frac{1}{2}} = \frac{\log_e 2 \times 6{\cdot}02 \times 10^{23} \times 5 \times 10^{-6}}{18{,}150 \times 226 \times 60 \times 60 \times 24 \times 365} \text{ years}$$

$$= 1{,}600 \text{ years (true value } 1{,}595 \text{ years).}$$

ASSAY OF ORES

The above determinations of the half lives of radioactive substances, while useful as an exercise, is not of much use to the amateur as the half lives of all the radioactive substances have been determined to a far greater degree of accuracy by professionals. The use of the above method, however, does enable the amateur to assay radioactive ores. The process is as follows.

Having determined the radioactive compound present by chemical analysis, a weighed sample of the ore is treated as in the above experiment. The half life and molecular weight of the specimen are taken from tables, leaving the weight of radioactive material present the only unknown factor.

Having determined this, the assay of the ore can be expressed as a percentage or as content of radioactive material per ton. To clarify this an example will be given.

Weight of uranium ore taken = 100 grammes
Molecular weight of uranium = 235
Avogadro number = 6·02 × 10^{23}
Rate count = 1,470 counts/sec.
Half life of uranium = 7·1 × 10^{8} years

$$\text{Constant for apparatus} = \frac{360}{11{\cdot}3}$$

$$t_{\frac{1}{2}} = \frac{\log_e 2LW}{RM} \text{(symbols as before, R = decay rate)}$$

Hence weight of radioactive material present is,

$$W = \frac{t_{\frac{1}{2}}RM}{\log_e 2L}$$

$$= \frac{7{\cdot}1 \times 10^{8} \times 60 \times 60 \times 24 \times 365 \times 235 \times 1{,}470 \times 360}{11{\cdot}3 \times 6{\cdot}02 \times 10^{23}}$$

$$= 0{\cdot}593 \text{ grammes.}$$

Hence, assay of material is 0·593 per cent of uranium 235.

EXAMINATION OF RAIN WATER

Readers will no doubt remember the consternation that was caused a few years ago by the discovery of radioactive iodine (I_{131}) in milk. The half life of this isotope is eight days so its presence can be easily detected by the first of the two methods described for determination of half lives. The iodine entered the milk via rain which fell on the pastures of cattle. The concentration of the isotope in the rain would be very small.

Investigation of radioactive material in rain first necessitates the concentration of the rain water. For this a special kettle reserved for the purpose should be used. About a gallon of rain water is collected. The kettle is filled with this water and boiled almost to dryness; it is then refilled and the process repeated until all the rain water collected has been concentrated (a gallon is the minimum for usable results).

The concentrate should be of the order of 50 to 100cc. This is then transferred to a conical flask of 250cc capacity where final concentration is carried out. The final volume should occupy about a half of one of the semi-micro test tubes.

The radioactivity of the specimen is observed over a period of time and a graph of count rate against time is plotted. One reading a day at the same time each day will be sufficient. If the graph adopts an exponential form, the half life of the radioactive material present can be found. Since the half life is peculiar to a particular nucleus, the substance present can be identified.

The specimen of rain water for concentration must be concentrated as soon as possible after it has fallen.

The above article by no means exhausts the possibilities of the use of the ratemeter, but it is hoped that it will serve as an introduction to radioactivity enabling the individual to devise his own experiments and lines of research. ★

DETACHED PARTICLES

By John Valence

IMPORTANT DATE

Perhaps it is not altogether irrelevant for me to mention the General Election. After all this did take place on the same day that Practical Electronics made its debut (yes, 15 October 1964 was certainly a date of importance!). Furthermore, electronics played a notable part in the election proceedings, both during the campaign as candidates vied with one another to appear the more foresighted in technological matters—the words electronics and automation are now very much part of the politician's stock-in-trade—as well as after the poll when some of the largest and fastest computers in the country were mobilised by the BBC, ITV, and the Press to analyse the results.

But was it lethargy on the part of the Elliott 803 in the BBC studio or inefficiency of the humans feeding this robot which produced the state of affairs where one commentator was able to obtain the answer on his slide rule in much shorter time?

A BIASED VIEW?

It is not, I trust, insularity on my part that makes me favour our term "valve" as opposed to the trans-Atlantic "tube". The latter word has always seemed to me a pretty inapt title for this important electronic device. All the more surprising that it was adopted by the Americans who generally have a gift for concocting imaginative and colourful terminology.

Actually I seem to remember reading sometime ago an admission by an American writer that the English term valve was a more appropriate choice than tube. The reason put forward in support of our word was rather odd though. It was suggested firstly that "valve" is synonymous with "amplifier", and secondly that all valves (or tubes) are amplifying devices.

What does this word valve in its general sense suggest to you? Do you think of, for example, a small lever or screw device controlling a large flow of liquid in a pipe line—if so then this is in truth an amplifier. Or do you visualise an object which is essentially a one-way device—such as the pneumatic tyre valve?

Coming back to the electronic valve, the one-way interpretation fits the envelope perfectly. On the other hand, the amplifier idea is logical all right when applied to triodes and upwards, but unfortunately excludes the humble diode.

SWEET AND LOW

Have you noticed how widespread the use of built-in background music is becoming? I really do mean "have you noticed". The sound that is nowadays being disseminated in many public places, shops, and restaurants is indeed of a very subtle character. It is far, far removed from the brash and forthright "music while you work" variety.

This background music is played more or less continuously and is designed not to intrude, but to be just audible. One may be hardly aware of the music—but sure enough it is doing its stuff on our subconscious mind!

Maybe it is all good therapeutic treatment, inducing calm into worried minds, and so aiding our digestive processes as we imbibe. Stores and supermarkets presumably find it commercially rewarding. The casual shopper, without realising exactly why, finds himself loath to depart from the comforting relaxing atmosphere, but lingers among the wares.

EXTRACTING THE FI

You may have your own ideas regarding the ethical or artistic aspects of this form of sound distribution. At any rate we can admire the technical expertise that has been applied to the planning and recording of programme material.

Musical items are carefully selected—strident sounds or heavily accentuated rhythmics are out. During the recording session amplitude compression is introduced, for it is essential that the sound level should remain constant throughout.

I suppose the engineers responsible for these recordings have their own particular problems and have no doubt evolved some ingenious circuits for their purpose. Perhaps it would be a trifle unfair to describe their end product as *no fi*.

But why employ all those musicians and then pass their recorded performance through an electronic mangle? Far more sensible to give the job to a computer, since this is an obvious case for synthesised music.

J.V. PREDICTS

Fashions do change, of course, and already I can see the next step: "Instal 'NOVOX' Ultrasonic Background System for that tranquil atmosphere . . . your clients will appreciate this aid to concentration when contemplating the menu or pondering over that special purchase . . ." etc., etc.

Ridiculous? I am not so sure.

A WEIGHTY MATTER

According to the theory put forward by an archæologist, Stonehenge—that monumental array of stone circles on Salisbury Plain—is a neolithic age computer, and was probably used to calculate the movement of the Sun.

Solid state, without a doubt.

He's a wizard at miniaturisation

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BUILD YOUR OWN RECORD PLAYER

4 Speed Autochange 2-tone Cabinets 17 × 15 × 8½in. High flux loudspeaker and 3 watt 2 valve amplifier ready built. Quality output. Volume and Tone controls. All items fit together perfectly. Special instructions enable assembly in 30 minutes, only 5 wires to join. 12 months' written guarantee.

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Garrard Autoslim	£12/18/- P.P.	5/-

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FULL WAVE BRIDGE SELENIUM RECTIFIER: 2, 6 or 12 v., 1½ amp., 8/9; 2 a. 11/3; 4 a., 17/6.
CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v., 1½ amps., 15/6; 2 amps., 17/6; 4 amps., 22/6. Circuit included.
4 AMP CAR BATTERY CHARGER with ammeter, Leads, Fuse Case, etc., for 6 v. or 12 v., 59/6.

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Size 1⅝in. sq. Precision jewelled bearings, 2%-accuracy, silvered dials, fine pointers, 0-1 mA. 27/6; 0-5 mA. 27/6; 0-300 V. 27/6; 0-50 μA 39/6; 0-500 μA 32/6. "S" meter 35/–

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4 TRANSISTOR PUSH-PULL AUDIO AMPLIFIER

Size 3 × 1¾ × ⅞in.
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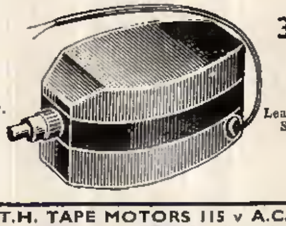

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200/250 v. A.C.

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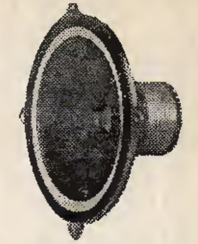

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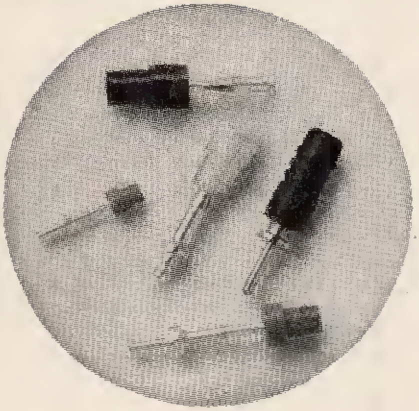

Miniature Insulators

Oxley Developments Company Ltd., Priory Park, Ulverston, Lancs.

It is easy for the amateur to purchase transistors, resistors and capacitors of miniature size. But try purchasing miniature accessories such as plugs, sockets and insulators for small work! Our photograph shows various types of miniature insulators, available to the amateur as well as professional, which are ideal for printed boards and perforated boards.

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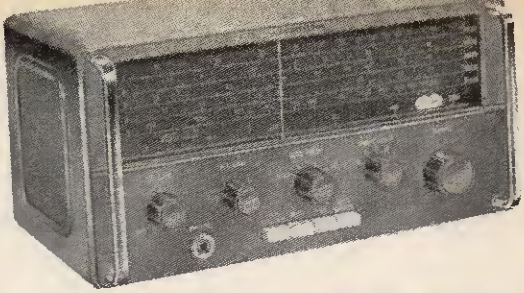

Communications Receiver

Stratton & Co. Ltd., Eddystone Works, Alvechurch Road, Birmingham 31.

A fully transistorised communications receiver which is in big demand is the Eddystone EC10. It has excellent performance throughout the 550kc/s to 30Mc/s range. Powered by six U2 type cells the current drain depends on the audio output, being 36mA quiescent, 77mA at 50 milliwatts output, and 180mA at 500 milliwatts. Independent r.f. and a.f. gain controls enable the gain to be balanced to suit strong or weak signals. As our photograph shows some of the controls are push button type. The b.f.o. pitch control has marked settings for reception of upper and lower sideband signals. The tuning control is flywheel-loaded and operates a gear drive with a reduction ratio of 110 to 1; frequencies are clearly marked on the large scale to a calibrated accuracy of within 1 per cent. Also, to allow dial settings to be recorded an auxiliary vernier and logging scale are incorporated in the tuning system.

The receiver is listed at £48 0s. 0d. in the U.K.

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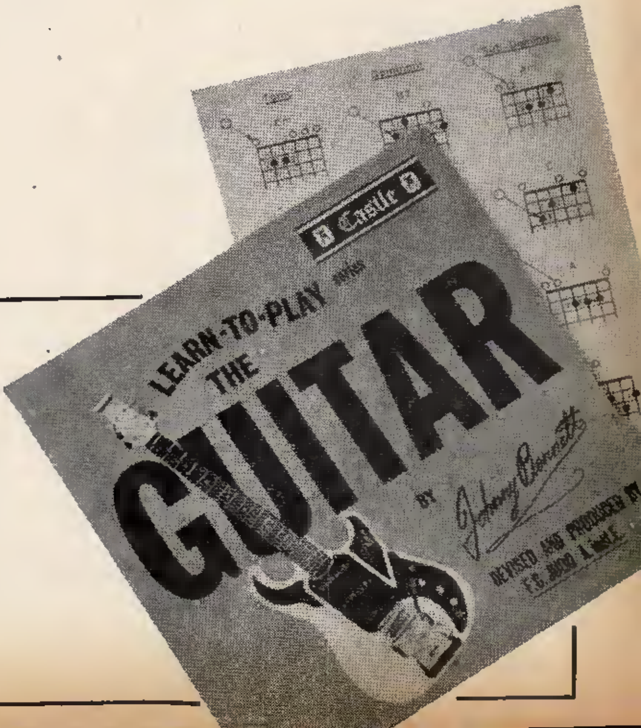

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We have full stocks of all components for the Mullard 510, Mullard 3-3, Mullard 2 and 3 Valve Pre-amp. Mullard Stereo, Mullard Mixer.
Fully detailed list on any of these sent upon request.
Instruction Manual: All Mullard Audio Circuits in "Circuits for Audio Amplifiers", 9/5. Post free.

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	Cash Price	Hire Purchase Deposit	Hire Purchase Mthly/Pmts.
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AVO Multiminor Mark 4	£9.10.0	£1.18.8	12 of 14/4
T.M.K. TP10	£3.19.6	£1. 3.6	3 of £1.2.0
T.M.K. TP5S	£5.19.6	£1.15.6	3 of £1.11.4
T.M.K. Model 500	£8.19.6	£1.15.6	12 of 13/8
TAYLOR MODEL 127A	£10.10.0	£2. 2.0	12 of 15/8

Full details of any of the above supplied free on request.
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Two track, Bradmatic Heads	£10.19.6	£2. 3.6	12 of 16/4
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We stock complete kits and all separate components for the Mullard Tape Pre-Amplifier. Fully detailed list available.

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GARRARD A.T.5 (Mono PU plug in head)	£10. 8.2	£2. 4.2	12 of 15/4
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FMT1, £6.12.6.; Mercury 2, £10.14.6.; JTV/2, £14.12.6.
Hire Purchase Terms available. Ask for list.

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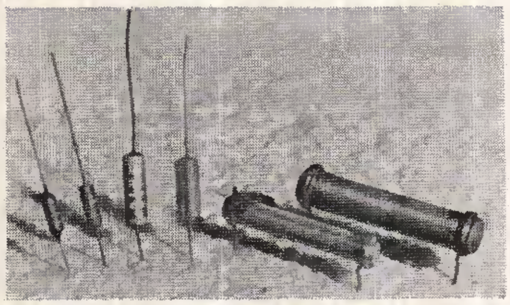

CARBON RESISTORS

A word or two now about *practical* resistors as used in electronic equipment. Last month we mentioned that wire wound resistors are not usually made in values greater than 100,000 ohms. In fact, the kind of resistor most commonly encountered in electronics is of the *carbon* fixed value variety.

Wire wound resistors have rather limited and specialised applications: they are used whenever a *precise* value of resistance is required; also as "voltage droppers" in power supply circuits, where high currents and voltages are involved. And of course, wire wound resistors suit our requirements perfectly in the present series of experiments.

One important thing to remember. All the basic laws that we are demonstrating for ourselves in this series of experiments hold good for all types of resistors—no matter whether they be made of wire, or of carbon or any other substance.

Last month we showed a group of typical wire wound resistors. This month our photograph shows a selection of carbon fixed-value resistors. These are the kind of components you will constantly be handling as you become involved in building electronic devices. A word or two about their characteristics—physical and electrical—will not be out of place at this stage.

There are two main types; carbon composition and carbon film.

Carbon *composition* resistors consist of a rod of carbon black or graphite. Connecting wires are wrapped around the ends of the rod and the latter is given a protective coating of paint. This type is known as *non-insulated.*

There are also insulated composition resistors. These are made by enclosing the rod of resistive material in a plastics moulding or ceramic tube. The connecting wires emerge straight out from the ends of the tube.

The film type of resistor is made by depositing a thin film of a carbon mixture upon a glass or ceramic tube or rod. The rod is encased in moulded plastics or in a ceramic tube. Outwardly, these resistors resemble the insulated composition type.

Most carbon resistors are colour coded. This colour code indicates the value in ohms and sometimes provides additional information. You will find the PRACTICAL ELECTRONICS Colour Code Calculator (presented with our first number) an extremely useful tool. If you have access to an assortment of resistors, it is a good idea to practice reading off the colours of a randomly selected component. Take our word for it—this will be to your benefit in the future.

RESISTORS IN PARALLEL

Our next exercise is to find out what happens when we connect resistors in parallel, that is, side by side instead of end to end. To do this you will need to connect the "shorting wire" of the last experiment to points A and C of the resistor and the slider contact to point B (see Fig. 2.1). You will find that the slider can be moved along the resistor from end to end and the bulb will now light all the time. Why is this so?

To enable you to understand quite clearly the present circuit arrangement, we have drawn an "intermediate" diagram: imagine the end A of the resistor bent back so that it nearly touches end C (Fig. 2.2), as you move the slider from the central position towards one end you are reducing the resistance of that branch and so increasing the current flow. The circuit is shown in its final and conventional form in Fig. 2.3.

As the bulb lights now at all positions along the resistor, it follows that the total resistance must be much less than the original short section (11cm) measured in the first experiment. Once again, we can calculate the value of the total resistance using a formula:

$$\frac{1}{R\ \text{total}} = \frac{1}{R1} + \frac{1}{R2}$$

Your resistance element has an approximate value of 75–80 ohms and hence you can mark the baseboard into divisions of, say, 5 ohms each. By setting the slider at any random point you can now read off the value of resistance either side of it. If the slider is set at 20 ohms (R1), the remaining resistance (R2) will be 60 ohms. Substituting these values in the above formula we get

$$\frac{1}{R\ \text{total}} = \frac{1}{20} + \frac{1}{60} = \frac{3+1}{60} = \frac{4}{60} = \frac{1}{15}$$

$$R\ \text{total} = 1/\tfrac{1}{15} = 15\ \text{ohms.}$$

We would like you to work out half a dozen calculations (one has already been done for you!) taking the value of R1 as 5 ohms, 10 ohms, 15 ohms, etc. and make a small list showing the values of R total, R1 and R2. You should find that the value of R total goes from 17½ ohms down to nearly 1 ohm.

You will see from this list that, when R1 is much smaller than R2, the total resistance or *equivalent* *resistance* is nearer R1 in value than R2. This can be very important in electronic circuits when you have a component with a resistance of perhaps 1,000 ohms in parallel with another component of 1 megohm. Let's do another calculation to show why:

$$\frac{1}{\text{R total}} = \frac{1}{1{,}000} + \frac{1}{1{,}000{,}000} = \frac{1{,}000+1}{1{,}000{,}000}$$

$$= \frac{1{,}001}{1{,}000{,}000}$$

Thus

$$\text{R total} = \frac{1{,}000{,}000}{1{,}001} = 1{,}000 \text{ ohms approximately.}$$

You can see then that if the value of one resistance is very high you can ignore it and consider only the value of the small one.

SECOND RESISTANCE ELEMENT

Now it is necessary to add the second resistance element to our apparatus. Here we use a 1,000 watt (1 kilowatt, or 1kW) fire element. Push the spare plastics knitting needle through the vacant hole in one of the wooden support pieces, thread it through the coiled element and insert in the hole provided in the second support. Ensure that the turns of wire are evenly spaced along the length of the needle.

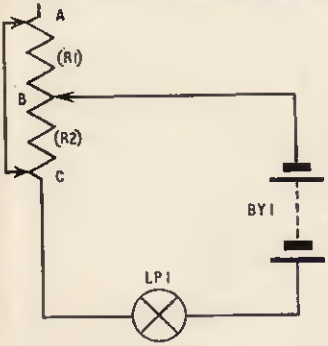

Fig. 2.1. The shorting wire is connected across the resistance element and sections R1 and R2 are thus in parallel

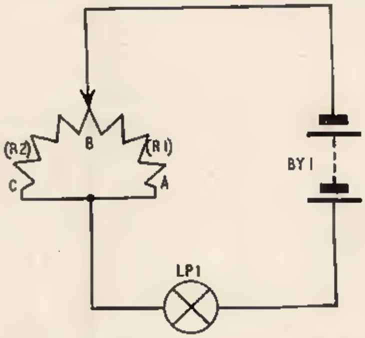

Fig. 2.2. This is the same set-up as Fig. 2.1 but the diagram has been redrawn to show more clearly the fact that R1 and R2 are in parallel

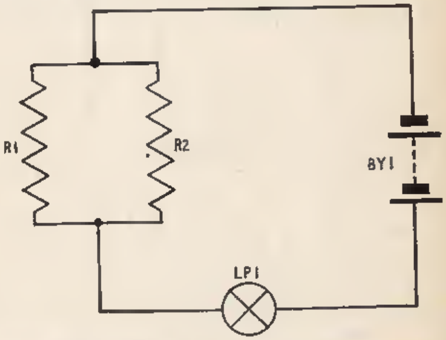

Fig. 2.3. Here, finally, the circuit is drawn in the normal, conventional manner

THE UNIT OF POWER

You may be wondering at this moment: what is meant by a kilowatt?

The basic unit of a watt is the unit of power that is the rate of doing work. To calculate the power in an electrical circuit you must multiply the voltage by the current; this is shown by the formula:

$$W = V \times I$$

where W stands for watts, V for volts, and I for current in amperes.

If you are unable to measure the voltage but know the resistance then you can use a second formula, which is

$$W = I^2 \times R \text{ (or } W = I \times I \times R\text{)}$$

A third form of the equation is

$$W = V^2 \div R \left(\text{or } W = \frac{V \times V}{R}\right)$$

If you look at the list of components in other articles in Practical Electronics, you will notice that resistors are quoted at ¼W, ½W, 1W, etc. This is as important in electronic circuits as having the correct value of resistance (in ohms). Say, for example, you had a resistance of 100 kilohms and a voltage of 300V, then the current flowing through it would be

$$\frac{300}{100{,}000} = 0{\cdot}003 \text{ amperes or 3mA.}$$

Working out the power as above ($W = V \times I$) would give

$$300V \times 0{\cdot}003A = 0{\cdot}9W$$

You would thus need a resistor rated at 1 watt and if you used one of perhaps ½ watt or ¼ watt then it would quickly overheat and break down. This heat is caused by the current flowing through the resistor and we use this to our advantage in electric fires, water heaters and electric light bulbs.

The higher the wattage rating of a carbon resistor, the larger its physical size. Refer to the photograph: the two smallest sized resistors are ¼W types, the next pair are ½W, and the other two 1W and 2W respectively.

Now to return to the experiments. If you have the two fire elements or coils wound on the needles you can experiment on your own by connecting them in different ways, shorting out sections of them and calculating the value of resistance in circuit. The 1kW coil will have a resistance between 50 and 55 ohms so you can mark out the base board in equal sections and measure off the resistance values direct.

You may also like to see the effect of increasing and decreasing the voltage to 6 volts and 3 volts respectively by substituting other batteries for the present 4½ volt battery. If you increase the voltage you will need more of the resistance in circuit to get the bulb just glimmering as compared with the amount needed with the 4½V supply. Obviously then you will have less resistance in circuit when a 3V battery is used.

We have used a bulb to indicate that current is flowing through the circuit and our next project is to make a simple type of meter that also tells us current is flowing. Many of you may have seen and used meters at school and know that there are many different types to measure voltage, current, resistance, etc.

Next month we will show you how to make a simple meter that you can set up with your battery and use for approximate measurements in later experiments.

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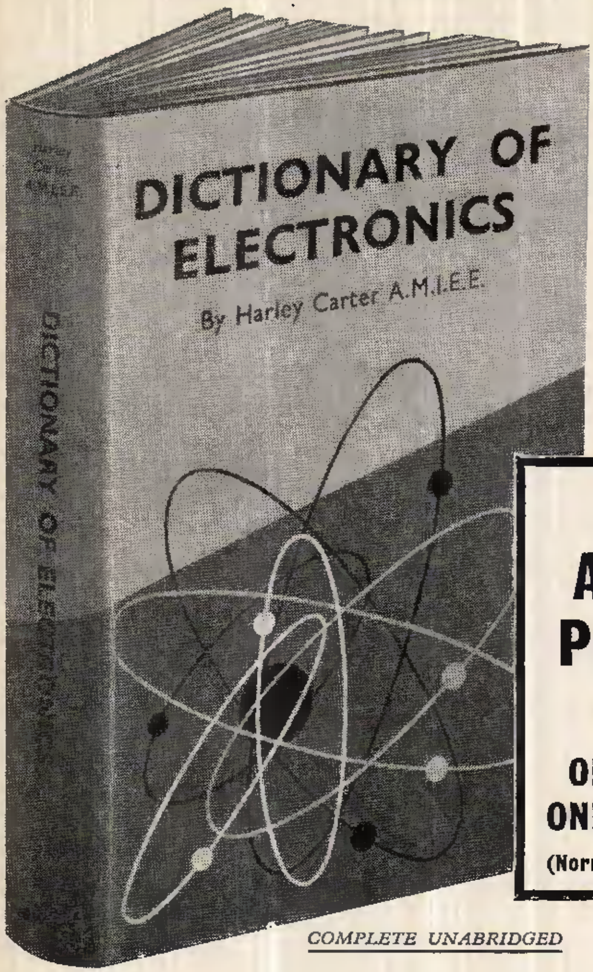

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ULTRASONIC REMOTE CONTROL

continued from page 118

Pack the space between the transducer and the wall of the top cap with foam rubber. A piece of ½in thick material, cut into a strip measuring approximately ¾in × 4in should serve this purpose adequately. Other similar material may be used, the important factor being to wedge the transducer firmly and centrally within the case.

Returning now to the bottom end of the case, first check that the battery can be accommodated inside, and recessed at least ⅛in from the bottom edge. If not, the transmitter assembly must be pushed gently upwards, but without, if possible, disturbing the transducer.

Solder a 1½in long lead (red coloured sleeving) to the metal strip which makes contact with the metal rim of the case. Fit the battery, base foremost, inside, ensuring that the blue and red leads are not trapped.

These two battery leads should extend about 1½in from the bottom of the case; cut off any surplus and solder these leads to the battery press stud connectors observing the correct polarity, i.e. red for positive, blue for negative.

Fit the connectors to the battery terminals and carefully push down the looped ends of the leads.

From a piece of stout cardboard, cut out a disc approximately ⅞in diameter. Place this disc over the battery before screwing on the end cap.

This cardboard insulating disc is essential, since the spiral spring connector in the end cap will be connected to the positive side of the battery when the cap is screwed home. The insulating disc prevents the spring coming into contact with the negative battery terminal—if this should happen the battery will be shorted.

SETTING UP

Place the transmitter so that its transducer is looking directly at the receiver transducer, and the two are not more than a couple of feet apart.

Connect an ohmmeter to the relay contacts, and connect the receiver battery.

Switch on the transmitter. Rotate the core of T1 until the relay operates, as indicated by zero reading on the ohmmeter. Withdraw the transmitter further from the receiver while making adjustments to T1 in order to obtain the optimum tuning point.

When the receiver is correctly adjusted, the relay should pull in at a current not exceeding 5mA with a d.c. supply of 4½V.

The receiver should response at a distance of at least 20ft from the transmitter.

This range can, however, be increased upwards to 100ft if OC44 transistors are used in the first three stages of the receiver (TR3–TR5) and simple cones are placed over the transducers. Paper cones tapering out to about 6in are quite effective for this purpose. ★

COMPONENTS . . .

Resistors

R1	8·2kΩ	R8	10kΩ	R14	10kΩ
R2	1kΩ	R9	100Ω	R15	560Ω
R3	5·6kΩ	R10	30kΩ	R16	12kΩ
R4	22kΩ	R11	47kΩ	R17	1·5kΩ
R5	1kΩ	R12	4·7kΩ	R18	15kΩ
R6	2·2kΩ	R13	12kΩ	R19	10kΩ
R7	5·6kΩ				

All ¼W carbon

Capacitors

C1	3,300μF silver mica	C5	22μF elect. 25V
C2	0·015μF disc ceramic	C6	0·015μF disc ceramic
C3	0·1μF disc ceramic	C7	5,000pF disc ceramic
C4	22μF elect. 25V	C8	1μF elect. 25V
		C9	50μF elect. 25V

Transistors

TR1–7 OC71 (7)

Miscellaneous

RLA Relay, 400Ω 5mA
T1 H.F. transformer (Osmor type QHF9)
X1, 2 Transducer (Gulton type 1404)
BY1 9V battery, Ever Ready PP3 or Exide DT3
BY2 9V battery
Two miniature coaxial plugs
Veroboard: one piece 4in × 4½in; two pieces 1½in × ¾in

Note: The Gulton transducers, the reed relay, and other essential components can be obtained from: DTV Group, 126 Hamilton Road, West Norwood, London S.E.27

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E.M.I. Separate Pick-up	**£3.0.0**	P.P. 3/6
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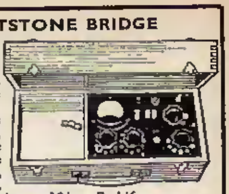

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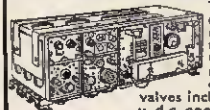

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New Condenser Parcel. Mixed. Send **6/-**. Post paid.

New 12in. Speaker with built in tweeter. 15 or 3 ohms. **28/6.** Post paid.

P.M. Speakers, all 3 ohm, ex-TV Sets. 6in. round, 6 × 4in. and 5in., 3/-. Post 2/-, 6 for **20/-**. Post paid. 8in. round, **6/-**. Post 2/-. 7 × 4in. **5/-**. Post 2/-.

VALVE LIST
Ex equipment. 3 months guarantee.
All Post Paid

EL91	1/6	20P3	4/-	PY80	3/-
ECL80	2/-	20P4	8/6	PL82	3/-
ECC82	3/-	20P1	4/-	PL83	3/-
EY51	2 6	30P4	8/-	PL33	3/-
EBF80	4/6	U801	8/6	PY81	3/-
EB91	9d.	U281	5/-	PY82	3/-
EL38	5/-	U232	5/-	PCF80	4/-
EY85	6/6	U329	5/-	PCC84	4/-
EF91	9d.	KT36	5/-	PCL85	6/6
6F1	1/-	KT66	8/-	PCL82	6/6
6F14	5/-	6V6GT	4/-	VR150/30	3/-
6F15	5/-	6B8	1/6	IT4	1/9
6LD20	5/-	6K25	5/-	12AT7	3/-
10C2	5/-	6P25	8/6	6CH6	1/6
10F1	1/-	6U4	5/-	6X4	3/-
10P13	5/-	PY33	6/6	R18	3/6
10P14	5/-	PL33	6/-	ARP12	1/6
20D1	2/-	PL81	4/-	807	5/6
20L1	5/-	PL38	8/-		

EF50 1/-, doz. 6/-; 6K7 1/3, doz. 10/-; 6V6 1/9, doz. 18/-; 6K8 1/9, doz. 18/-.

Send S.A.E. for rare valve enquiry.

Breaking up Mark III Type 19 Sets. Meter, 500 microamp., 5/-. Post 1/9. Jack Socket 1/-. Post 6d. Doz. 10/-. Post paid. Jack 1/5. Post 6d. Toggle Switch Metal 6d. Post 6d. Doz. 10/-. Post paid. Relay Type 3000 1/9. Post 1/9. Doz. 20/-. Post paid. Any other spare send 2/- plus post to cover.

TV Sets. 13 channels. Untested but complete. 14in. 30/- 17in. 50/-. Carr. 10/-. **Well packed but sent at owner's risk.**

Reclaimed Tubes Six months guarantee. 14in. Mullard and Mazda 17/-. Carr. 7/6. 17in. 30/-. Carr. 7/6.

LASKY'S RADIO

For the Finest Value and Service to the HOME CONSTRUCTOR AND THE ELECTRONICS ENTHUSIAST

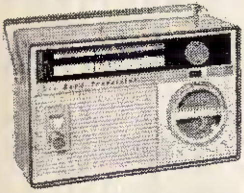
We consider our construction parcels to be the finest value on the home constructor market. If on receipt you feel not competent to build the set, you may return it as received within 7 days, when the sum paid will be refunded less postage.

TRANSISTOR PORTABLES

THE SKYROVER AND SKYROVER DE LUXE

★ **LONG WAVEBAND COVERAGE IS NOW AVAILABLE FOR THE SKYROVER and SKYROVER DE LUXE.** A simple additional circuit provides coverage of the 1100/1950M band (including 1500 M. Light programme). This is in addition to all existing Medium and Short wavebands. All necessary components with construction data. Only **10/-** **extra Post Free.**

This conversion is suitable for Skyrover and Skyrover De Luxe receivers that have already been constructed.



GENERAL SPECIFICATION
7 transistor plus 2 diode superhet, 6 waveband portable receiver.
The SKYROVER and SKYROVER DE LUXE cover the full Medium Waveband and Short Waveband 31-94M, and also 4 separate switched band-spread ranges, 13M, 16M, 19M and 25M, with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is completely factory assembled, wired and tested. The remaining assembly can be completed in under three hours from our easy to follow, stage by stage instructions.

SPECIFICATION:
Superhet, 470 Kc/s. All Mullard Transistors and Diode. Uses 4-U2 batteries. 5in. Ceramic Magnet P.M. Speaker. Easy to read Dial Scale. Band Spread Tuning. 500 MW Output. Telescopic Aerial and Ferrite Rod Aerial.

WAVEBAND COVERAGE: 180-567M; 31-94M and Band Spread on 13, 16, 19 and 25 metre Bands.

The SKYROVER

Controls: Waveband Selector, Volume Control with on/off Switch, Tuning Control. In plastic cabinet, size 10 × 6½ × 3½in. with metal trim and carrying handle.

Can now be built for **£8.19.6** P. & P. 5/- extra.

H.P. Terms: £1 deposit and 11 monthly payments of 16/6.

The SKYROVER De Luxe

Tone Circuit is incorporated, with separate Tone Control in addition to Volume Control. Tuning Control and Waveband Selector. In a wood cabinet, size 11½ × 6¾ × 3in. covered with a washable material, with plastic trim and carrying handle. Also car aerial socket fitted.

Can now be built for **£10.19.6** P. & P. 5/- extra.

H.P. Terms: 25/- deposit and 11 monthly payments of 20/-.

Data for each receiver: 2/6 extra. Refunded if you purchase the parcel. **Four U2** batteries 3/4 extra. All components available separately.

REALISTIC SEVEN

Fully tunable long and medium bands. Uses 7 Mullard Transistors: plus Diode OA70.
STAR features:
● 7 Transistor Superhet. ● 350 Milliwatt output 4in. high flux speaker. ● All components mounted on a single printed circuit board, size 5½in. × 5½in. in one complete assembly. ● Plastic cabinet, with carrying handle, size 7in. × 10in. × 3½in., in blue/grey. ● Easy to read dial. ● External socket for car aerial. ● I.F.-frequency 470 Kc/s. ● Ferrite rod internal aerial. ● Operates from PP9 or similar batt. ● Full comprehensive data supplied with each Receiver. ● All coils and I.F.s etc., fully wound ready for immediate assembly. An outstanding Receiver.

Can be built for

£5 . 19 . 6

P. & P. 4/6.

REALISTIC SEVEN De Luxe

By popular request a De Luxe version of the well-known Realistic Seven now available. With the same electrical specification as standard model—PLUS A SUPERIOR WOOD CABINET IN CONTEMPORARY STYLING covered in attractive washable material, with super-chrome trim and carrying handle. Also a full vision circular dial, externally mounted to further enhance the pleasant styling. **ONLY £1 EXTRA**

Both models: Battery 3/9 extra. (All components available separately.) Data and instructions separately 2/6, refunded if you purchase parcel.

TWO SINCLAIR SUPER MINIATURES

THE MICRO-6 Self-contained pocket radio. Size only 1 4/5 × 1 3/10 × ½in. A marvel of modern miniaturisation—truly amazing performance. Without a doubt the most advanced transistor circuit ever offered to home constructors—yet may be built in an evening. Complete with earphone and detailed construction data. **Can be built for only** **59/6** All parts sold separately. Mercury cell 1/11 extra (2 required).

THE SLIMLINE The new amazing performance 2-transistor pocket radio size only 2¾in. × 1¾ × 1¼in. Micro alloy transistorised and printed circuit. Easy to assemble. **CAN BE BUILT FOR** **49/6** All components available separately.

TRANSFILTERS **By BRUSH CRYSTAL CO. Available from stock.**
TO—01B 465 kc/s. ± 2 kc/s.
TO—01D 470 kc/s. ± 2 kc/s.
TO—02B 465 kc/s. ± 1 kc/s.
TO—02D 470 kc/s. ± 1 kc/s.
TF—01B 465 kc/s. ± 2 kc/s.
TF—01D 470 kc/s. ± 2 kc/s.
6/6 EACH
P. & P. 6d.

CONSTRUCTORS BARGAINS

The "Sixteen" Multirange METER KIT

This outstanding meter was featured by *Practical Wireless*, in the Jan. '64 issue. Lasky's are now able to offer the complete kit of parts as specified by the designer.

RANGE SPECIFICATION:
D.C. volts: 0-2.5-25-50-250-500 at 20,000Ω/V.
A.C. volts: 0-25-50-250-500 at 1,000Ω/V.
D.C. current: 0-50μA, 0-2.5-50-250 mA.
Resistance: 0-2000Ω, 0-200kΩ, 0-20 MΩ.
Basic movement: 40μA f.s.d. moving coil. With universal shunt full scale deflection current is 50μA.
Size/finish: Black plastic case—3¾ × 5¾ × 1¾in.
Controls: 12 position range switch: separate slide switch for A.C. volts—D.C. ohms; ohms zero adjustment pot. meter; meter zero. External connections: Two 4 mm. sockets for test lead plugs.

Power requirements: One 15v. and one 1.5v. batts. Complete with all parts and full construction details.

LASKY'S PRICE **£5.19.6** · P. & P. 5/-.

H.P. Terms: 21/- deposit and 5 monthly payments of 21/-. Data and circuit available separately, 2/6; refunded if all parts bought. Pair of batteries 2/- extra.

BUILD A HIGH QUALITY TAPE RECORDER

Using the famous Collaro "STUDIO" deck and MARTIN pre-assembled amplifiers 2- or 4-track models.

COLLARO STUDIO TAPE DECK. Latest model 3 speed, 3 motors. Take 7in. reels. Fitted with half-track heads. **LASKY'S PRICE £10/10/-.** - New and Unused. Carr. & Pack. 7/6.

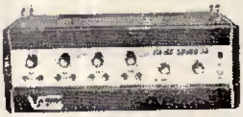
COLLARO STUDIO TAPE DECK. As above but fitted with the latest quarter-track heads. **LASKY'S PRICE £13/19/6.** Carr. & Pack. 7/6.

MARTIN TAPE RECORDER AMPS. Designed for use with Collaro Studio Tape Deck. In sub-assemblies for immediate installation. 6-valve circuit. Comprehensive instructions make final assembly as simple as possible. Everything supplied including valves, etc. Monitoring facilities. 3-ohm output, speed equalising, etc. For 200-250 v. A.C. mains.

PRICES ½-track Model **£11/11/-.** ¼-track Model **£12/12/-.** P. & P. 2/6. Portable carrying case designed to take the Collaro Studio Tape Deck and the Martin Tape Amplifier. Fitted with 9 x 5in. speaker. Price complete with speaker **£5/5/-.** P. & P. 5/-.

SPECIAL INTEREST ITEMS!

VIKING "SOUND 30" AMPLIFIER



High quality guitar and P.A. amplifier. A.C. Mains operated—30 watt output. 8 inputs. Fitted with 4 separate volume controls for mixing also bass and treble controls. 15 ohms out. impedance. British made—highest quality components used throughout—fully guaranteed. In strong portable case, size approx. 20 × 9 × 6in.

LASKY'S PRICE **35 GNS.** Carr. & Pack. 7/6 extra.

NEW! ANOTHER SINCLAIR SUPER MINIATURE

THE X10 10 watt power amplifier fitted with integrated pre-amplifier. Requires only 1 mV. for an output of 10 watts undistorted. Frequency response is flat ½ dB from 5 c/s. to 20 kc/s. Size only 6 × 3 × ¾in. Weight 5 oz. Built on printed circuit. Operates from 12 v. D.C. at 75 mA. quiescent. Circuit uses 7 M.A.T.s and 4 RF power transistors. **KIT PRICE** **£5.19.6** Post Free

AVAILABLE READY BUILT, TESTED AND GUARANTEED, £6.19.6 Post Free. 3 pots. for volume, Bass and Treble, 7/6 the 3 extra. Mains power pack if required, **54/-.**

DEAC RECHARGEABLE NICKEL CADMIUM CELLS

Rating 1.22 v. 3.5 A.H. at 10 hour rate. 1,001 uses for model makers, miniature electronic equipment, portable radios, transistor radios, T.V's, tape recs., transceivers, photo flash, etc. Hermetically sealed. Size 3¼ × 1⅜ × 1⅜in. Listed at 35/- each.
LASKY'S PRICE 15/- each. POST FREE. BANK of 9, 79/6.

THE HARROW POWER PACK

Battery eliminator for portable radios, etc. Converts your battery radio to A.C. mains. Replaces 4½ v., 6 v. and 9 v. batts. Size only 3in. × 2in. × 2½in. State voltage required when ordering.

LASKY'S PRICE **29/6** P. & P.

TRANSISTORS

ALL BRAND NEW AND GUARANTEED

GET 81, GET 85, GET 86 2/6; 837A, 874P 3/6; OC45, OC71, OC81D 4/6; OC 44, OC 70, OC 76, OC 81 (match pair **10/6**); AF 117, 5/6; OC 75, OC 170, OC 200 6/6; OC 23, OC 42, OC 43, OC 73, OC 82D 7/6; OC 201, OC 204 15/-; OC 205, OC 206 19/6; OC 28 24/6.

207 EDGWARE ROAD, LONDON, W.2.
Near Praed St. PADDINGTON 3271/2
BOTH OPEN ALL DAY SAT. Early Closing Thurs.

33 TOTTENHAM COURT ROAD, W.1.
Nearest Stn., Goodge St. MUSEUM 2605
Mail Orders to Dept. P.W., 207 Edgware Rd., W.2.

152/3 FLEET STREET, LONDON, E.C.4.
Telephone: Fleet Street 2833
OPEN ALL DAY THURSDAY. Early Closing Sat.

LASKY'S FOR SPEEDY MAIL ORDER SERVICE

TYGAN FRET (Contem. pat.), 12 × 12in. 2/-; 12 × 18in. 3/-; 12 × 24in. 4/-, etc.
EXPANDED ANODISED METAL—Attractive gilt finish ¼ in. × ½ in. diamond mesh 4/6 sq. ft. Multiples of 6 in. cut. Max. size 4ft. × 3ft., 47/6, plus carr.
ENAMELLED COPPER WIRE—½lb. reels 14g-20g. 2/6; 22g-28g. 3/-; 30g-34g. 3/9; 36g-38g. 4/3; 39g-40g. 4/6, etc.

Volume Controls—5K-2 Meg. ohms, 3in. Spindles. Morganite Midget Type 1¼in. diam. Guar. 1 year. LOG or **LIN** ratios less Sw. 3/-. DP. Sw. 4/6. Twin Stereo less Sw. 6/6. DP. Sw. 8/-. **Specials to order.**

SPECIAL BARGAIN

½ Meg. VOL. Controls DP. Sw. ¼" flatted spindle. Famous Mfrs. 4 for 10/-, post free.

BONDACOUST Speaker Cabinet Acoustic Wadding (1in. thick approx.) 12in. wide, any length cut, 1/6 ft., 4/- yd. **TINNED COPPER WIRE.** 16-22g. 2/6 ½lb. **ERSIN MULTICORE SOLDER.** 60/40 4d. per yard. Cartons 2/6, etc.

New Boxed VALVES Reduced Bargain Prices

1T4	3/6	ECC83	7/-	PCC84	8/-
1R5	6/-	ECL82	10/-	PCF80	8/-
1S5	6/-	ECL80	9/-	PCL83	10/6
3S4	7/-	EF80	7/6	PCL84	10/-
3V4	7/-	EF86	8/6	PL81	9/6
DAF96	8/-	EL84	7/-	PL82	9/-
DF96	8/-	EY51	9/-	PL83	8/-
DK96	8/-	EY86	9/-	PY32	10/6
DL96	8/-	EZ81	7/-	PY81	8/-
ECC81	7/-	GZ32	9/6	PY82	7/-
ECC82	7/-	EM84	8/6	U25	10/6

CO-AX 80 ohm CABLE

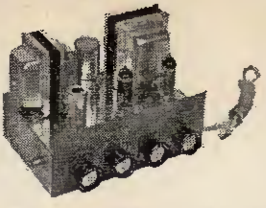
High grade low loss Cellular Air Spaced Polythene—¼in. diam. Stranded-Cond.

Now only 6d. yard

BARGAIN PRICES—SPECIAL LENGTHS 20 yds. 9/-; P. & P. 1/6. Coax. Plugs 1/-; 40 yds. 17/6; P. & P. 2/-. Sockets 1/-; 60 yds. 25/-; P. & P. 3/-. Couplers 1/3.

MULLARD "3–3" HI-FI AMPLIFIER

3 VALVES 3 WATT



3 ohm and 15 ohm Output. A really first-class Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit: Valve line-up: EF86, EL84, EZ81. Extra H.T. and L.T. available for Tuner Unit addition. This is the ideal companion Amplifier for FM tuner units.

TECHNICAL SPECIFICATION—Freq. Response: ±1dB. 40 c/s-25 kc/s. Tone controls, max. treble cut 12dB at 10 kc/s. Max. Bass Boost 14dB at 80 c/s sensitivity: 100MV for 3W output. Output Power (at 400 c/s): 3W at 1% total harmonic distortion. Hum and Noise Level: At Least 70dB below 3W.

COMPLETE KIT (incl. valves, all components, wiring diagram and special quality sectional Output Trans.) **BARGAIN PRICE £6.19.6** carr. 4/6. Complete wired and tested, **8 gns.** Wired power O/P socket and additional smoothing for Tuner Unit, **10/6** extra.

Bronze Escutcheon Panel, Printed Vol., Treble, Bass, On-Off, supplied with each kit.
Recommended Speakers—R. Allen 12" with tweeter **42/6**, WBHF10-12 **£4.7.6**, Goodmans Axiette **£5.5.0**, Axiom 10 **£6.5.0**, Audiom 51 **£8.10.0.** Carr. extra.

RECORDING TAPE

Famous American Columbia (CBS) Premier quality tape at NEW REDUCED PRICES. A genuine recommended Quality Tape—TRY IT. Brand new, boxed and fully guaranteed. Fitted with leader and stop foils.

Standard		Double Play		Long Play	
5" 600'	13/-	1,200'	31/6	900'	17/6
5¾" 900'	16/-	1,800'	37/6	1,200'	19/6
7" 1,200'	21/-	2,400'	47/6	1,800'	28/6

Post & Package per reel, 1/- plus 6d. each for additional reels.

SPECIAL OFFER 3" Message tape 150', 3/9; 3" L.P. 225', 4/9; 3" D.P. 300', 6/6. P. & P. per reel 6d.
TAPE REELS Mnfrs. surplus 7", 2/3; 5¾", 2/-; 5", 2/-; 3", 1/3; Plastics spool containers, 5", 1/9; 5¾", 2/-; 7", 2/3.

Speakers P.M.—3 ohms 2½" E.M.I. 15/6. Goodmans 3½" 16/6. 5" Rola 15/6. 6" Elac 16/6. 7" × 4" Goodmans 15/6. 8" Rola 19/6. 10" R. × A. 25/-. 9" × 6" Goodmans 22/6. E.M.I. Tweeter 22/6. **Jack Plugs.** Standard 2½" Igranic Type, 2/6. Screened ditto, 3/3. Miniature scr. 1½", 2/3. Sub-min. 1/3.

TRANSISTOR COMPONENTS

Midget I.F.'s—465 Kc/s $\frac{5}{16}$ in. diam.	5/3
Osc. Coil M. & L.W.	5/9
Midget Driver Trans. 3.5:1	6/9
Midget Output Trans. Push-Pull—3 ohms	6/9

Elect. Condensers—Midget Type 1 mfd.-50 mfd. ea. 1/9, 100 mfd. 2/-, 12V.
Condensers 150 v. working: .01 mfd., .02 mfd., .03 mfd., .04 mfd. **9d.**; .05 mfd., .1 mfd., **1/-**; .25 mfd., **1/3**; .5 mfd., **1/6**, etc.
Midget Tuning Condensers. J.B. "OO" 208 pF and 176pF, **8/6**; ditto with trimmers, **9/6.** J.B. 220pF and 105pF conc. slow motion **10/6.** 365pF single **7/6.**

Condensers—Silver Mica. All values 2pF to 1,000pF, **6d.** each. Dittos Ceramics **9d.** Tub. 450V T.C.C. etc. 0.001 mFd to 0.01 and 0.1/350V. **9d.** 0.02-0.1/500V., 1/-, 0.25 Hunt, 1/6. 0.5 T.C.C. **1/9**, etc., etc. **Close Tol. S/Micas**—10% 5pF-500pF, **8d.** 600-5,000pF, 1/-. 1% 2pF-100pF, **9d.** 100pF-500pF, **11d.** 575pF-5,000pF, **1/6.** **Resistors**—Full Range 10 ohms-10 meg. ohms 20% ½ and ¼W, 3d., ⅛W, 5d. (Midget type modern rating) 1W, **6d.**, 2W, **9d.** **Hi-Stab.** 5% ¼W, ½W, **6d.** (100 ohms-1 meg). Other values **9d.** 1% ¼W, **1/6**, etc., etc.

TRIMMERS, Ceramic (Compression Type)—30pF, 50pF, 70pF, 9d.; 100pF, 150pF, 1/3; 250pF, 1/6; 600pF, 1/9.
PHILIPS. Bee Hive Type (conc. air spaced)—2-8pF, 1/-; 3-30pF, 1/-.
KNOBS—Modern Continental types. Brown or Ivory with Gold Ring; 1" dia., 9d. each; 1½", 1/- each; Brown or Ivory with Gold Centre, 1" dia., 10d. each; 1½", 1/3 each. LARGE SELECTION AVAILABLE.
METAL RECTIFIERS. STC Types—RM1, 4/9; RM2, 5/6; RM3, 7/6; RM4, 16/-; RM5, 21/-; RM4B, 17/6.

TUB-ELECTROLYTICS-CAN

25/25v. 50/12v. 1/9; 8+8/450v. 4/6; 50/50v. 100/125v. 2/-; 32 + 32/275v. 4/6; 8/450v. 4/350v. 2/3; 50/50/350v. 6/6; 16 + 16/450v. 5/6; 60/250/275v. 12/6; 32 + 32/450v. 6/6. 100 + 200/275v. 12/6.

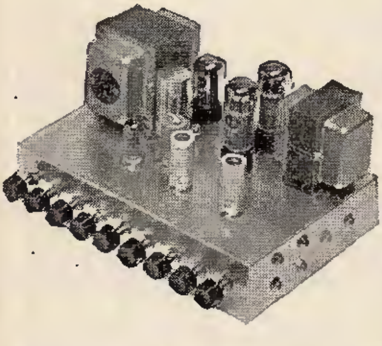
TRS

Est.
1949

RADIO COMPONENT SPECIALISTS

70 Brigstock Rd., Thornton Heath, Surrey. *Hours: 9 a.m.-6 p.m., 1 p.m. Wed.*
THO 2188. *Terms C.W.O. or C.O.D. Post and Packing up to ½ lb. 9d.; 1 lb. 1/3; 3 lb. 2/3; 5 lb. 2/9; 8 lb. 3/6.*

GUITAR AMPLIFIERS WITH TREMOLO



Five jack socket inputs, four with separate mixing volume controls, and one input "straight through". All inputs are of very high sensitivity only 10 millivolts input is required for full output, making them suitable for all types of guitars and microphones. Separate Bass and Treble controls, giving a wide range of lift and cut. Separate master gain control. Tremolo speed and depth controls. Jack socket for remote tremolo switching. Outputs for 3 and 15 ohms speakers. Valves used in the 30 watt and 50 watt amplifier ECC83, ECC83, EL34, EL34, GZ34. In the 15 watt amplifier ECC83, ECC83, EL84, EL84, EZ81. An extra valve ECC83 is used in the tremolo circuit. The chassis is complete with baseplate and is solidly made of 18 gauge steel, finished silver grey hammer.
Size 12 × 8 × 6½ inches high.

PRICES—

50 watt with tremolo	**£20.10.0**
50 watt less tremolo	**£19.10.0**
30 watt with tremolo	**£15.10.0**
30 watt less tremolo	**£14.10.0**
15 watt with tremolo	**£12.10.0**
15 watt less tremolo	**£11.10.0**

Add carriage 10/- any amplifier. Send for free descriptive leaflet.

STROUD AUDIO

PAGANHILL LANE, STROUD, GLOS. Stroud 733

PARKER'S SHEET METAL FOLDING MACHINES

NEW BENCH MODEL

Capacity 36in. wide x 18-gauge mild steel. Forms channels and angles down to 45 deg., which can be flattened to give safe edge. Depth of fold according to height of bench. Will form flanges.

Weight approx. 2 cwt.

Price £23/0/0, carr. free. Also the well-known vice models of:

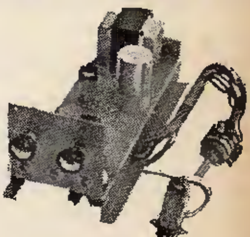
36in. x 18-gauge capacity ...	£11	10	0	*Carriage free*
24in. x 18-gauge capacity ...	£6	15	0	
18in. x 16-gauge capacity ...	£6	15	0	

One year's guarantee: money refunded without question if not satisfied. Send for details:

A. B. PARKER, Wheatcroft Works

WELLINGTON STREET, BATLEY, YORKS. Tel. 426

HIGH QUALITY TAPE AMPLIFIER KIT



Suitable for use with tape decks having a high impedance record head and a low impedance erase head. Magic eye recording level. 3 ohm 4 watt output. 2 inputs with tone control. Provision for monitoring. Simple point to point wiring instructions. This tape amplifier is also available completely built and tested. Ideal for use with Collaro and B.S.R. decks.

Kit Price £7.10.0
Ready Built £9.17.6
p & p 3/6

ELECTROSURE LTD., Fore Street, Exeter

CLEAR PLASTIC PANEL METERS

First grade quality. Moving Coil panel meters, available ex-stock. S.A.E. for illustrated leaflet. Discounts for quantity. Available as follows:

Type MR. 38P. 1 21/32in. square fronts.

50μA	32/6	1A D.C.	29/6
100μA	29/6	5A D.C.	22/6
200μA	27/6	3V D.C.	22/6
500μA	25/-	10V D.C.	22/6
50-0-50μA	29/6	20V D.C.	22/6
100-0-100μA	27/6	50V D.C.	22/6
500-0-500μA	22/6	100V D.C.	22/6
1-0-1mA	22/6	150V D.C.	22/6
1mA	22/6	300V D.C.	22/6
2mA	22/6	500V D.C.	22/6
5mA	22/6	750V D.C.	22/6
10mA	22/6	15V A.C.	22/6
50mA	22/6	50V A.C.	22/6
100mA	22/6	150V A.C.	22/6
150mA	22/6	300V A.C.	22/6
200mA	22/6	500V A.C.	22/6
300mA	22/6	"S" Meter 1mA	29/6
500mA	22/6		
750mA	22/6		

Type MR.52P. 2½in. square fronts.

50μA	57/6	100mA	32/6
100μA	47/6	1A D.C.	32/6
500μA	37/6	300V D.C.	32/6
50-0-50μA	57/6	300V A.C.	32/6
100-0-100μA	47/6	"S" Meter 1mA	39/6
1mA	32/6		
10mA	32/6		

Type MR.65P 3½ × 3¼in. fronts

50μA	59/6	1mA	35/-
100μA	49/6	10mA	35/-
500μA	39/6	100mA	35/-
50-0-50μA	59/6	1A D.C.	35/-
100-0-100μA	49/6	300V D.C.	35/-
VU meter	59/6	300V A.C.	35/-

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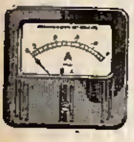

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50-0-50μA	42/6	*50A A.C.	29/6
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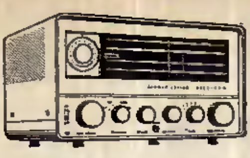

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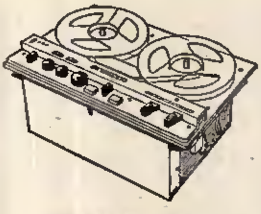

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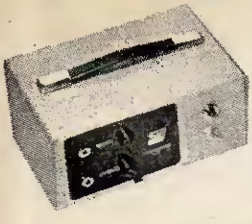

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350-0-350v	80mA 0-4-6.3	4A 0-4-5v	2A	21/9
250-0-250v	100mA 0-6.3v	4A 0-5v	2A	27/6
350-0-350v	100mA 0-6.3v	4A 0-5v	2A	27/6
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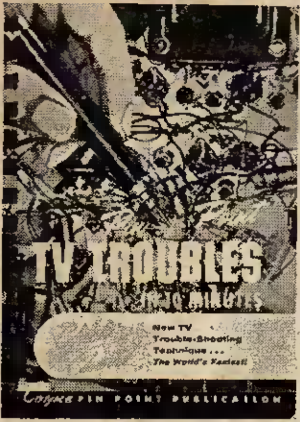

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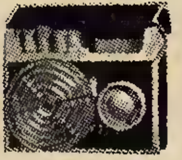

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